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Woody biomass for energy market: towards a new estimation of the consumption and production levels in Italy and a comparative analysis between Italy and Spain

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Abbreviations and acronyms

AEBIOM	European Biomass Association
AIEL	*Associazione Italiana Energie Agroforestali*
APAT	*Agenzia per la Protezione dell'Ambiente e per i Servizi Tecnici*
ARPA	*Agenzia Regionale Protezione Ambiente*
AVEBIOM	*Asociación Espanola de la Biomasa*
BEN	*Bilancio Energetico Nazionale*
CFS	*Corpo Forestale dello Stato*
CHP	Combined Heat and Power
CNE	*Comisión Nacional de la Energía*
CO_2	Carbon Dioxide
DHS	District Heating System
EC	European Commission
ENAMA	*Ente Nazionale per la Meccanizzazione in Agricoltura*
ENEA	*Ente Nazionale per le nuove tecnologie, l'Energia e l'Ambiente*
EU	European Union
EUROSTAT	Statistical Office of the European Communities
FAO	Food and Agriculture Organization of the United Nations
FIPER	*Federazione Italiana Produttori Energia*
FLA	*Fondazione Lombardia Ambiente*
GHGs	Green House Gases
GSE	*Gestore Servizi Energetici*
IDAE	*Instituto para la Diversificación y Ahorro de la Energía*
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPLA	*Istituto per le Piante da Legno e Ambiente*
ISPRA	*Istituto Superiore per la Ricerca Ambientale*
ISTAT	*Instituto Nazionale di Statistica*
ITABIA	Italian Biomass Association
JWEE	Joint Wood Energy Enquiry
LCV	Lower Calorific Value
MAGRAMA	*Ministerio Agricoltura e Medio-Ambiente*
MINIETUR	*MInisterio de la Industria, Energía y Turismo*

MiPAAF	*Ministero per le Politiche Agricole, Alimentari e Forestali*
MISE	*Ministero dello Sviluppo Economico*
MS	Member State
NREAP	National Renewable Energy Action Plan
RDP	Rural Development Program
RED	Renewable Energy Directive
RES	Renewable Energy Sources
SRF	Short Rotation Forestry
UNECE	United Nations Economic Commission for Europe

Units of measurement

m^3	Cubic Meter
t	Ton
toe	Ton Oil Equivalent
W	Watt
J	Joule

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Summary

The use of woody biomass for energy has seen a continuous growth in the last years in industrialized countries. In many European countries, among them Italy, an important role has been given to wood-energy in the framework of the EU Renewable Energy Strategy for 2020. An importance driven by several benefits but that also raises important challenges in the forestry sector. Nonetheless, a problem of lack and inconsistency of data characterizes the European energy-wood market, one of the main limiting factors to an effective assessment and forecast of its contribution as a Renewable Energy Source.

In this thesis we aimed at a better estimation of the wood-energy market in Italy through a review and consistency analysis of the informative sources and data available. The main component of our work were two estimations: one focused on households consumption based on the ISTAT “Survey on consumption by families”; the second one was aimed to evaluate the domestic supply based on expert’s opinion through a Delphi survey. Finally, a comparative analysis of the wood energy markets in Italy and Spain has been carried out.

We concluded giving evidence that the wood energy market informative framework for Italy is inconsistent and the current statistical data available are not suitable for an accurate quantification and monitoring of the market and related policies. We provided some new estimates of the apparent consumption of wood for energy based on experts’ opinion. In order to promote more adequate sectorial policies the value chain organization and the levels of wood resources domestic supply should be further investigated.

1. Introduction

Climate change mitigation, together with other factors such as the concern for a growing energy demand, rising fossil fuel prices and the dependency for many countries on energy imports are the major drivers that at global level are boosting the development and use of Renewable Energy Sources (RES), namely, sources from which energy can be produced that can be renewed indefinitely, such in the case of hydro-, solar, geothermal and wind, or which can be sustainably produced, such as biomass (FAO, 2007). Specifically, the term biomass for energy (*or* bioenergy) refers to all those types of energies produced from woodfuels deriving from woody biomass sources, agro-fuels from agricultural biomass, or other biofuels types (FAO, 2004). The specific focus of this thesis is on woodfuels and woody biomass for energy, or more in general the wood-energy sector, which composes the largest part of bioenergy share.

Bioenergy has been defined by the International Energy Agency (IEA) as the "sleeping giant" among the RES, referring to its role and potential as the first RES at global level. Bioenergy provides infects about the 10% of global primary energy supply, albeit, the models of utilization and efficiency varies significantly according to the level of industrialization of the countries and the availability of conversion technologies for energy production (Berndes *et al.*, 2003). Indeed, the large part of biomass, about 75% (IEA, 2010), is still used in traditional systems for covering basic energy needs in developing countries, but also in many industrialized countries the use of biomass for energy has seen a continuous growth over the last years (Steierer, 2007). A growth driven on the one hand by market forces, and on the other hand by specific policy measures and investments in research and innovation, in the framework of sustainable and renewable energy production (Hillring, 2003). In the European Union (EU), the Renewable Energy Directive 2009/28/EC assigns to bioenergy a strategic role. According to the Directive, the EU Member States committed to reach by 2020 the overall target of 20% gross energy consumption from RES, implementing National Renewable Energy Action Plans (NREAPs) with specific targets and measures (Beurskens and Hekkenberg, 2011). In Italy for instance, according to the NREAP approved in June 2010, the main target is to produce by 2020 the 17% of the gross energy consumption from RES, in which bioenergy will cover about the 44 %, within the electricity, heat and transportation sectors.

As mentioned previously, the main component of bioenergy is woody biomass. The two main reasons behind this heavy reliance on woody biomass for energy in Italy and the EU are, firstly, the cost-effectiveness of the raw material and, secondly, its large availability accumulated in forests (Verkerk *et al.*, 2011). Afterwards, there are other general advantages that make

woody biomass competitive against the other RES, such as the opportunity to enhance active forest management of frequently abandoned or semi-abandoned forests (Moiseyev *et al.*, 2011), to valorize residues and wastes from forest-based industries (Steubing *et al.*, 2012), improving income and quality of life in rural areas (Wolz *et al.*, 2011). However, this growing role of wood-energy in Europe raises also several critical issues and challenges related to the availability of resources (Mantau *et al.*, 2008), the potential impacts of increased woody biomass harvesting on forest protection (Johannes and Giuliana, 2014), biodiversity and other ecosystems services provision (Pedroli *et al.*, 2012) and, moreover, on competitive wood uses, for example the pulp and wood-based panel industry (UNECE/FAO, 2006).

Furthermore, in several EU countries, including Italy, there are problems concerning the lack and inconsistency of data on consumption of woody biomass for energy. This is in general considered to be related with the cross-sectorial character and fragmentation of the market itself (Steierer, 2007). Wood-energy data are indeed related with energy, forestry and industry statistics, which are provided by agencies and institutions often working with no coordination and using different definitions and units of measurements (ESFC, 2008). In addition, due to the multiplicity of sources on the supply side from which woody biomass derives and the presence of different submarkets and final users on the demand side, the wood-energy market is particularly fragmented and complex to be clearly defined and quantified. In the specific case of Italy, a coherent quantification of the woody biomass for energy market has not been made (Ciccarese *et al.*, 2012; Pettenella and Andrighetto, 2011). Inspite a considerable amount of available data and information are available, this is very uncertain and there are often relevant discrepancies between official data provided by the National Institute of Statistics (ISTAT) and estimates made by other studies (Pettenella and Ciccarese, 2009; Corona *et al.*, 2007; Magnani, 2005). In recent years, some studies stated that even the assumption relative to consumption levels of woody biomass made in the NREAP are strongly underestimated (Ciccarese *et al.*, 2012; Pettenella and Andrighetto, 2011).

Consequently, the inconsistency of the informative framework and the lack of a solid and coherent market estimation can be major limiting factor to an effective assessment and forecast of the role of woody biomass for energy as a RES in the national energy budget, also to be able to guarantee the sustainable growth of the sector and harvesting levels in the domestic supply of wood resources. These issues are particularly important in front of the expected remarkable increase of the demand for woody biomass in Italy and Europe in the next years in the framework of the 2020 targets and also in the perspective of a more long-term regulatory framework for RES promotion. Thus, it emerges the urgent need to investigate more on the real

role of the wood-energy in Italy, critically assessing the existing data used in the current energy policies' planning assumptions and contributing to a better definition and estimation of the market.

On the bases of these background problems, the thesis overall objective is to improve the knowledge and understanding of the wood-energy market in Italy. In particular, this work aims at contributing to a better estimation of the woody biomass for energy market, focusing on the internal production and consumption levels, and assessing the available informative sources and data on the market.

The specific objectives are:

i. to present an overview of the current state of the woody biomass for energy market in Italy based on a comprehensive review and consistency assessment of the statistical and literature sources and data available;
ii. to contribute to a better estimation of the woody biomass for energy market in Italy, focusing firstly on households' consumptions based on the analysis of the ISTAT "Survey on consumption by families", and secondly on the internal production of woody biomass, based on experts' opinion;
iii. To present a comparative analysis of the current state of the woody biomass for energy market between Italy and Spain in order to assess the quality and availability of data in comparison with other countries.

The thesis is structured into eight chapters. The second chapter (*Chapter 2 – Background*) presents the relevant background information used within the thesis, including definitions and categorization of the woody biomass for energy market. An overview on RES and woody biomass in the European Union is then provided, with a focus on the 2020 targets defined by the Renewable Energy Directive. Special attention is then paid to present the Italian National Renewable Energy Action Plan and the problems related to inconsistency of the data on which this document is based.

In the third chapter (*Chapter 3 – Research methodology*) the research methodology is described with a presentation of the research approach, the informative sources and methodologies used in data collection and analysis. A section is dedicated also to the limitations of the present work.

The following four chapters are dedicated to the results and the discussion of the thesis. In the fourth chapter (*Chapter 4 – Review and assessment of the wood-energy market informative sources and data available*) the current state of the Italian woody biomass for energy market is presented, with an exhaustive review of statistical and literature sources and data

available and an assessment of their consistency based on experts' opinion. The following chapter (*Chapter 5 – Fuelwood consumption at household level based on ISTAT "Survey on consumption by families"*) presents the results of the analysis of the ISTAT's survey focusing on household consumption of fuelwood, providing interesting insights on usage and expenditure for fuelwood and also trying to provide a new estimation of the consumption at household level based on the survey's information. Chapter six (*Chapter 6 – A tentative estimation of the production levels based on experts' opinion*) presents the result of the Delphi survey questionnaires conducted involving a panel of experts in order to tentatively estimate the production levels of woody biomass in Italy.

The last of the results' chapters (*Chapter 7 - A comparative analysis between Italy and Spain*) presents the comparative analysis between the wood-energy market informative sources and data in Italy and Spain.

The conclusions that have been drawn from the results of the study are found in the last chapter (*Chapter 8 – Conclusions*).

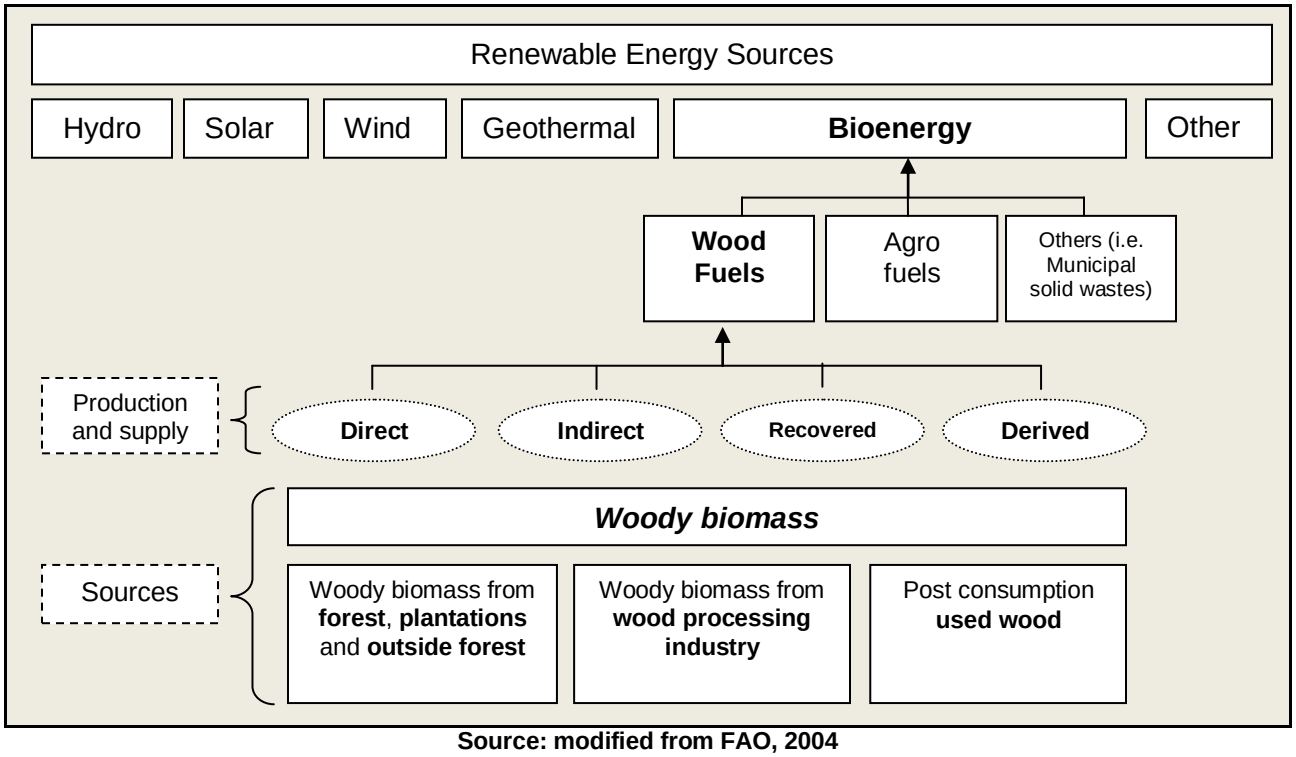
2. Background

This chapter introduces the relevant background information used within the thesis, including definitions and categorization of the wood-energy market (2.1), with an overview of the woody biomass for energy use in an international perspective and the main advantages and limitations influencing it. Moreover, a section on RES and woody biomass in the EU is provided (2.2), with the current situation and the expected developments towards the 2020 targets defined by the Renewable Energy Directive. Special attention is paid then to present the Italian National Renewable Energy Action Plan and its targets, and the problems related to lack and inconsistency of data on which this document is based.

2.1 Woody biomass as a Renewable Energy Source

The focus of this thesis is on the market of woodfuels and all sources of woody biomass from which are derived, or more in general the wood-energy market. The conceptual framework adopted in this work is shown in a graphical scheme in Figure 1.

Figure 1: Conceptual framework of RES and woodfuels sources



Source: modified from FAO, 2004

To find a common definition and categorical scheme of wood-energy at international level is a difficult task, and this is mainly because of the complexity of the market itself, which comprises several sources, conversion methods, final users and sub-markets. Several authors and international agencies have proposed different classifications in order to facilitate the interpretation of the information and data on woodfuels and woody biomass sources in an international common framework. In this thesis, we try to follow the terminology proposed by the Food and Agriculture Organization of the United Nations (FAO) in the Unified Bioenergy Terminology (UBET) (FAO, 2004), which has been developed and published with the aim to improve the definitions and classification of bioenergy data and information at international level. The UBET terminology framework has then been adapted and integrated in order to be able to better describe the study context of this thesis, which is the EU and in specific Italy.

2.1.1 Woody biomass for energy market

Woody biomass sources and supply*:* According to the Unified Bioenergy Terminology (FAO, 2004) wood-energy refers to all those energies derived from woodfuels, which are defined as "*all types of biofuels derived directly or indirectly from woody biomass*". Woody biomass arises from forests and from other sources (See Table 1), which can be classified as:

- Woody biomass from forest, plantations and outside forest: including biomass from forest deriving from silvicultural activities, biomass deriving from plantation as for example from Short Rotation Forestry (SRF), and biomass from trees outside forest as in the case of urban forestry, vineyards, olive groves, other woody crops etc.
- Woody biomass derived from wood processing industry*:* biomass in the form of by-products and residues deriving from sawmills and wood processing activities, as endings, cross-cut shavings, saw dust, wood panels by-products, etc., and black liquor from pulp mills.
- Post consumption used wood: including for example wood waste, demolition wood, recovered construction wood and used paper used at the end of the cycle for energy production (FAO, 2004).

Table 1: Examples of biomass sources

	Woody biomass from forest, plantations and outside forest	Woody biomass from wood processing industry	Post consumption used wood
Examples	Complete tree Tree sections Thinning by-products Logging by-products Energy forest trees Energy plantation trees Short rotation trees Slabs Shrubs Stumps Bark	Endings Cross-cut ends Wood shavings Grinding dust Saw dust Particle/fiber board by-products Plywood by-products Fiber sludge Black liquor	Wood waste from urban area Demolition wood Recovered construction wood Wood bulk waste Used paper

Source: modified from FAO, 2004

For what concern the production and supply of woodfuels deriving from woody biomass, according to FAO (2004) four chains are distinguished:

- Direct woodfuels: which are directly removed from forests, plantations and trees outside forest and used in energy production;
- Indirect woodfuels: including all those woody by-products, residues and wastes deriving from wood processing and related- industries (i.e. sawmills, panel industry, pulp and paper industry, carpentry etc.).
- Recovered wood fuels: deriving from activities outside the forest and wood-processing sectors. In this category are included the post consumption used wood directed to energy production.
- Wood-derived fuels: referring to those fuels produced from woody sources using various conversion processes. They include liquid and/or gaseous fuels made from ligno-cellulosic conversion and pyrolysis.

Wood-energy demand and final users: On the bases of the demand side, woodfuels enters in the energy production process in various physical forms and with different moisture content and chemical composition (See Table 2). We distinguish three categories:

- Solid woodfuels: This is the prevalent category, comprising fuelwood and charcoal. As fuelwood we intend wood and woody products which are destined directly to energy, as firewood, or transformed into woodfuels, as wood chips and pellets. Firewood stands for wood logs removed directly from forest that are used as energy without further treatments or conversion. Pellets and briquettes, which are products

made of dried and pressed wood characterized by very low moisture content, mainly produced from wood processing industries wastes and residues. Wood chips are intended as wood chipped in the form of small pieces and particles through a mechanical treatment, which can derive from variety of woody biomass sources.

- Liquid woodfuels: including black liquor, methanol and pyrolitic oil etc.;
- Gaseous woodfuels: including those products from the gasification and pyrolisis gases.

Table 2: Woodfuels categorization according to production and supply

User side and demand	Examples
Solid	Fuelwood (firewood, chips, pellets, briquettes, sawdust) and charcoal
Liquid	Black liquor, methanol, pyrolitic oil etc.
Gaseous	Other products from gasification and pyrolisis gases of wood fuel

Source: modified from FAO, 2004

As mentioned at the beginning, the use of wood-energy comprises different sub-markets and final users. These can be divided in residential sector, power and heat commercial sector and industrial sector. In specific:

- Residential sector: at household level woodfuels are used in stoves, fireplaces and small-size boilers with a medium-low level of efficiency (around 50%), using mainly traditional fuelwood. Also pellet-based applications are becoming more and more available and can have much higher levels of efficiency (over 80%). Wood chips, also used at household level but at a lesser extent, are more used, together with pellets, in boilers and small size heating system in woodworking and wood related industries and in district heating systems at public level.
- Power and heat commercial sector: including large scale power plants, which can produce only electrical power, generated from the turbines driven by the heat and steam from biomass combustion, or in the case of Combined Heat and Power (CHP) installations also heat, which is captured from the process and can be used in District Heating Systems (DHS), able to provide heat up to several thousand households. For these productions wood chips are mainly used.

- Industrial sector: referring mainly to forest-based industries, which can generate electricity or heat from their woody residues and wastes, either for internal use or for selling to third parties.

Finally, for what concerns the transportation sector the role of woodfuels (liquid or gaseous) is minor, compared to other types of biofuels. Advanced biofuels based on woody biomass are in fact not yet being well developed and produced on a large scale, although technological innovations and improvement will allow in the future a more efficient and competitive use.

2.2.2 Woody biomass as a Renewable Energy Source in an international perspective

According to the International Energy Agency (IEA) at global level bioenergy accounts for about 10% of primary energy consumed (IEA, 2010). Different is the estimation provided by the Food and Agriculture Organization of the United Nations (FAO), which estimates the contribution of bioenergy to the global primary energy consumed at around 15%, in which wood-energy represent about the 87% (FAO, 2004). This discrepancy is due to the difficulty in gather accurate data on the wood-energy market on international bases (Steirer, 2007).

Indeed, in an international perspective the use of woody biomass for energy and the development stage of the bioenergy sector varies significantly according to the level of industrialization of the countries, the availability of new technologies for bioenergy production and efficiency (Berndes *et al.*, 2003).

In terms of wood-energy use, a general differentiation is made between traditional and "modern" woodfuels use (Antila, 2009).

Traditional use refers the direct use of unprocessed woody biomass for basic energy needs as cooking and heating at household level in low-efficiency stoves and fireplaces. This is the typical situation of many developing countries and accounts for about the 75% of the global use (IEA 2010). In many developing countries indeed, biomass often the dominating source of energy at household level, estimated to account for between 30 and 90% of the total energy supply of these countries according to the IEA (IEA, 2010). The highest share is in sub-Saharan Africa, but also many countries in Latin America and South Asia rely heavily on biomass sources, mainly in the form of self-consumed firewood, charcoal, and agricultural residues, and this happens for a variety of reasons, including cultural preferences, availability and economic factors (Denirbas, 2008).

However, also in many industrialized countries - where wood was the main source of energy until the industrial revolution and replaced firstly by coal and then by fossil fuels - the use of biomass for energy has seen a continuous growth over the last years (Steierer, 2007). Indeed, in these countries wood-energy is nowadays regaining its historical importance as a "modern" RES. "Modern" woodfuels are distinguished from the traditional ones because woodfuels are used in modern and higher efficiency applications and systems at residential, commercial and industrial level, within the heat and power sectors.

This renewed role of wood and woody biomass as a source of energy has been driven on the one hand by market forces and on the other hand by specific policy measures and investments in research and innovation, in the framework of ambitious plans for increasing the share of renewable energy and reducing GHGs emissions (Moiseyev *et al.*, 2011; Thornley and Cooper, 2008; Hillring, 2003). Woody biomass, in fact, as stated in some of the main international conventions on climate change and energy (*i.e.* Kyoto protocol) as well as in the EU Renewable Energy Directive, is considered to be a carbon-neutral energy source. The reason is that the trees (or plants) harvested and used in energy production are coming from sustainably managed forests or plantations and replaced by new growing ones, with harvest rates that do not exceed the growing rate and the Carbon Dioxide (CO_2) emitted during the production transportation processes does not exceed the CO_2 sequestered during the stand growth (FAO, 2008).

Main advantages and limitations of woody biomass over the other Renewable Energy Sources: This renewed role wood-energy is due not just to the opportunity that sustainably produced woodfuels have to reduce GHGs emission, but also because of several others factors that from the energy production standpoint than makes this energy source competitive over the other RES. According to FAO (2004) these are:

- the advantage of being a "stored energy", this is an important feature compared to the daily or seasonal intermittent solar, wind and small hydro sources which have high costs of energy storage.
- Wood-energy gives an opportunity to valorize residues and wastes both from silvicultural activities in forest and outside forest and from wood processing industries. Residues which are converted from a substantial disposal costs to valuable bioenergy resources for the industry.
- The valuable rural and economic development potential, mainly in terms of income and employment due of the labour-intensive disposition of the wood-energy market.

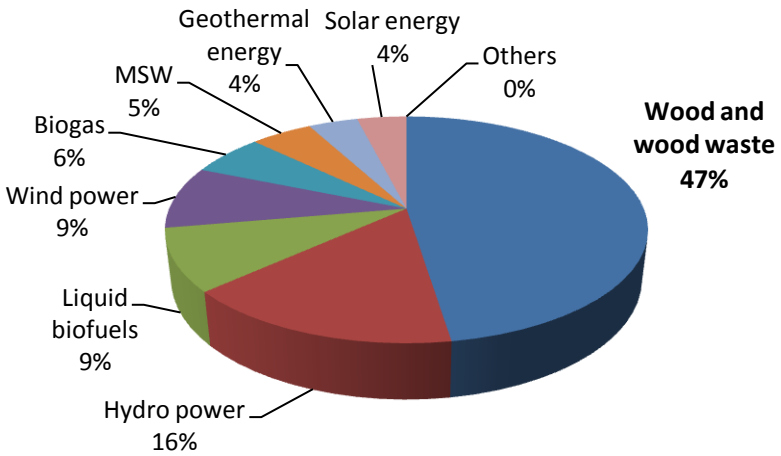
However, wood-energy presents also several limitations that have to be taken into account, concerning mainly:

- the sustainability of the supply from forest, in relation with the risk of land degradation, conversion from natural and semi-natural ecosystem to plantations, loss of biodiversity and other forest ecosystem services.
- The strong dependence on local context elements, such as economic and technical factors related to forest utilization and access to the resources, in terms of competitiveness.
- The diversified and competitive final uses that woody biomass has, with risks related to effective policies implementation. For example a major competing demand is between energy production and wood-based panels industry or pulp and paper industry.
- The information level, which is generally lower than for other RES.

2.2 Renewable energy and woody biomass in the European Union

In 2011, according to the Energy Statistics 2013 report published by the Statistical Office of the European Communities (Eurostat), the share of RES in gross inland energy consumption in the EU was approximately 10% (7,077 Petajoules). Of this share, wood and wood waste have central role, covering the 47%, as shown in Figure 2, resulting as the first RES in the EU (Eurostat, 2013a).

Figure 2: Share of RES in gross energy consumption in EU in 2011

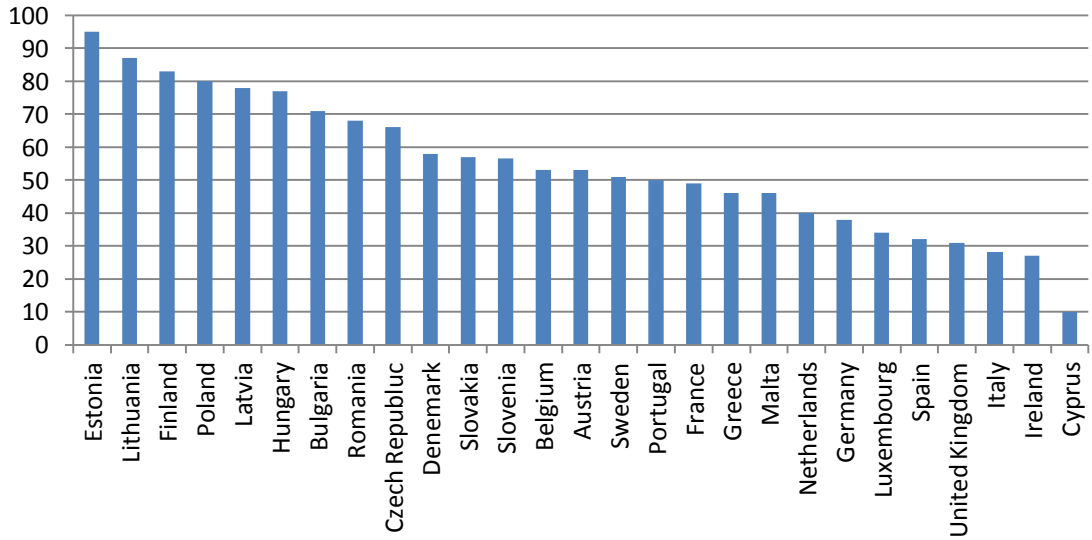


Source: Eurostat

More in specific, according to Eurostat, the main categories used for woodfuels energy production are primarily fuelwood from forests (49%); post consumption used wood (20%), wood waste and residues (17%) and black liquor (15%). This varies then among the EU member states, for example, in Ireland and Lithuania is wood waste that plays the major role (more than 60%), while black liquor is used mostly in Northern countries like Sweden and Finland (Eurostat, 2013a). Among the fuelwood, a sector that had a notable growth in the last years in the EU is the pellet sector. The consumption of wood pellets for heating has indeed grown by more than one million ton per year since 2010, amounting at about eight million tons in 2012 according the European Biomass Association (AEBIOM), making the EU the main pellet market globally (AEBIOM, 2013).

Among the member states, Baltic and Northern European countries are the ones that rely more on wood-energy, with a contribution of more than 80% to the RES share. The share of wood and wood waste in gross inland consumption from RES in EU member states according to Eurostat is showed in Figure 3.

Figure 3: Share of wood and wood waste in gross consumption from RES in EU member states



Source: Eurostat

It is noteworthy that even though Eurostat – which is the responsible for data collection and presentation at community level - is taken as a reference for official data, EU statistics are still far from having a solid and coherent informative framework consistent with the data that other agencies and institution provides data on renewable energy and woody biomass, such as the European Biomass Association (AEBIOM), EurObserv'er and the United Nations Economic

Committee for Europe (UNECE). Indeed, these agencies often work with different focuses and using different definitions. For instance, while Eurostat adopt the category “wood and wood waste” in its energy statistics, EurOserv’er in its “Solid Biomass Barometer” report, use the categories of heat and electricity produced from “solid biomass”, not distinguishing between woody biomass and biomass from agriculture and other sources (EurObserv’er, 2013). The same happens for the other informative sources, and as a result, the general informative framework provided on wood-energy in the EU presents several discrepancies and inconsistencies in data (Andrighetto, 2011).

Box 1: The renewable energy policies of the European Union

The political debate on renewable energy in the EU started in the 1990s, after the approuval of the United National Framework Convention on Climate Change (UNFCCC) hold in Rio de Janeiro in 1992 and the Kyoto Protocol in 1997. The goals of reducing GHGs emissions guarantee energy security and diversify the energy sources mix are central elements of the EU energy policies.

The bases of the current EU strategy on renewables have been outlined with the White Paper for a Community Strategy and Action Plan “Energy for the future: Renewable sources of energy” adopted in 1997 by the European Commission (EC). In this document the EC proposed indicative targets for renewable energy technologies development in the 2010 horizon.

Consecutive to the white paper, the European Parliament adopted in 2001 the Directive 2001/77/EC, setting indicative target for the production of electricity power from RES. The target was to reach a general 22.1% of total electricity consumption from RES by 2010, in which each member state had a national indicative target and the duty of monitoring and reporting the progresses.

Two years later, with the Directive 2003/30/EC indicative targets also for the production of biofuels and other fuels from RES have been set.

The main policy measure of the EU for renewable is the Renewable Energy Directive (RED) 2009/28/EC, which for the first time set mandatory targets on RES. EU member states committed to reach a general 20% share of final energy consumption from RES by 2020, and a 10% in the transportation sector. Additionally, the Directive set a 20% target for the reduction of GHGs emissions compared with 1990 levels and a non-binding target of increasing by 20% energy efficiency. The directive requires all member states to prepare a National Renewable Energy Action Plan (NREAP) to implement the European Directive, including the definition of specific national targets and measures to reach these targets.

Recently, the European Commission (EC) issued the Green paper “A 2030 framework for climate and energy policies”, which indicates new targets beyond 2020, proposing to increase the share of final energy consumption from RES a 30% by 2030, together with a 40% improvement in energy efficiency and a reduction of 40% of GHGs compared with 1990 levels. At the time this thesis was written the European Parliament voted (in February 2014) in favour of binding 2030 targets but the negotiation was still ongoing.

2.2.1 Expected developments under the Renewable Energy Directive 2009/28EC

In the EU, objectives such as increasing the share of energy produced from RES, reducing GHGs, improving energy efficiency, and reducing dependence on instable fossil fuel markets are the core elements of the current energy policy. Objectives that are strongly supported by specific policies, incentives-schemes and investments in research and innovation (Solberg *et al.*, 2014; Thornley and Cooper, 2008). An overview of the main recent renewable energy policies of the EU, starting from the 90s with the beginning of the international debate on climate change and energy and the ratification of the Kyoto agreement till nowadays, is presented in Box 1.

The most important policy measure in force at the moment in the EU is the Directive 2009/28/EC, called also Renewable Energy Directive (RED), which defines the 2020 target for the share of gross energy consumption from RES for each member state. According to the Directive, the main targets for 2020 are:

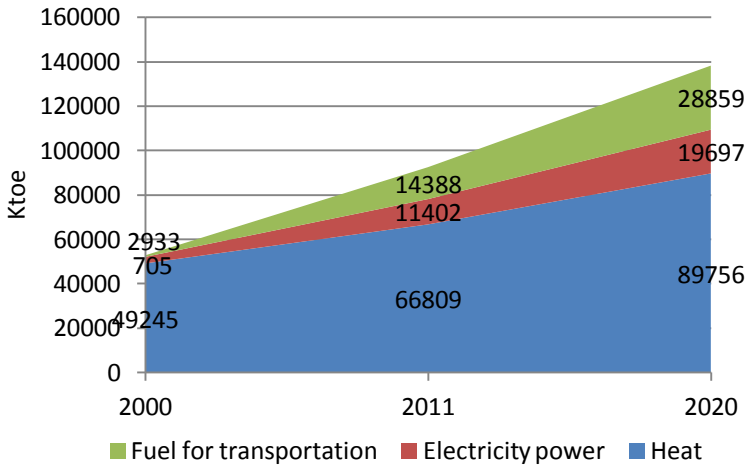
- to reach a 20% share of energy from renewable sources;
- reach a 10% share of renewable energy in the transport sector;
- Two non-mandatory objectives of improving also energy efficiency (by 20%) and reduce in general energy consumption.

Each member state is required to approve a National Renewable Energy Action Plans (NREAP) with specific measures in order to achieve these targets (Beurskens and Hekkenberg, 2011) (See Chapter 2.3.1 for the Italian NREAP).

The consumption of woodfuels, which has more than doubled since the year 2000, is expected to increase in the future as a consequence of the RED 2020 targets. In Figure 4 the progress of bioenergy towards the 2020 is presented.

As it can be observed, the heat sector plays the major role, expected to reach by 2020 the 65% of the total bioenergy use (89,756 Ktoe). However the electricity and fuels for transportation sector are the ones where the major growth is expected in terms of percentage variation. Electricity indeed is expected to account for the 20% of bioenergy use (19,697 Ktoe), compared to the 15% of 2011. Concerning the fuels for transportation, this is expected to reach the 14% of the bioenergy use (28,859 Ktoe), although this last target is considered to be very unlikely to be reached (AEBIOM, 2013).

Figure 4: Progress and forecast of bioenergy towards 2020



Source: AEBIOM, 2013 with data from Eurostat and NREAPs

Consequently to this increase of bioenergy over the RES share, also the pressure on wood resources is expected to remarkably growth. In a much quoted study, Mantau *et al.* (2010) quantified the expected increase in woody biomass supply from European forests in an 11% from 2010 to 2030. The two main reasons behind the role the wood-energy has in Europe among the RES are firstly the cost-effectiveness of the raw material, especially if we compare to the large investment that the other RES as solar or wind implies, and secondly the large availability of biomass accumulated in the nearly 200 million hectares of European forests (Verkerk *et al.*, 2011). This has raised an intense debate at scientific level on the potentials and challenges that this implies, and on the strategies to adopt in order to guarantee the sustainability of the sector and of the resources (Muys, 2013; Söderberg and Eckerberg, 2013; WWF, 2012).

On the one hand, in additions to the previously state general advantages of wood-energy over the other RES, an increased demand for woody biomass in the EU is considered to be a major opportunity especially for:

- Improving income and quality of life of rural areas and develop a green economy (Wolz *et al.*, 2010)
- enhancing an active management of nowadays abandoned forests exposed to fires and pests risks (Moiseyev *et al.*, 2011);
- maximizing the mobilization and cascade use of wood (Steubing *et al.*, 2012);

However, on the other hand it also raises several critical issues and sustainability challenges related to:

- the availability of resources in Europe (de Wit and Faaij, 2010; Hetsch, 2008);
- Potential implications in terms of sustainable utilization of forests, forest protection, biodiversity and other ecosystem services provision (Johannes and Giuliana, 2014; Pedroli *et al.*, 2012).
- The competition between demand for wood energy and forest-based industries, especially wood-based panels industry (Söderberg and Eckerberg, 2013; UNECE/FAO, 2006;).

Moreover, this increasing demand will indeed inevitably lead to increasing import from countries outside EU, raising further challenges concerning the carbon balance and the legal provenience of woody biomass.

2.2.1 The Italian Renewable Energy Action Plan 2010-2020

In Italy, the bioenergy sector has experienced a continuous growth over the last decade, and has an important contribution for energy production from RES. This positive trend is expected to continue in the next future, especially as a result of the 2020 renewable energy targets (Scarlat *et al.*, 2013).

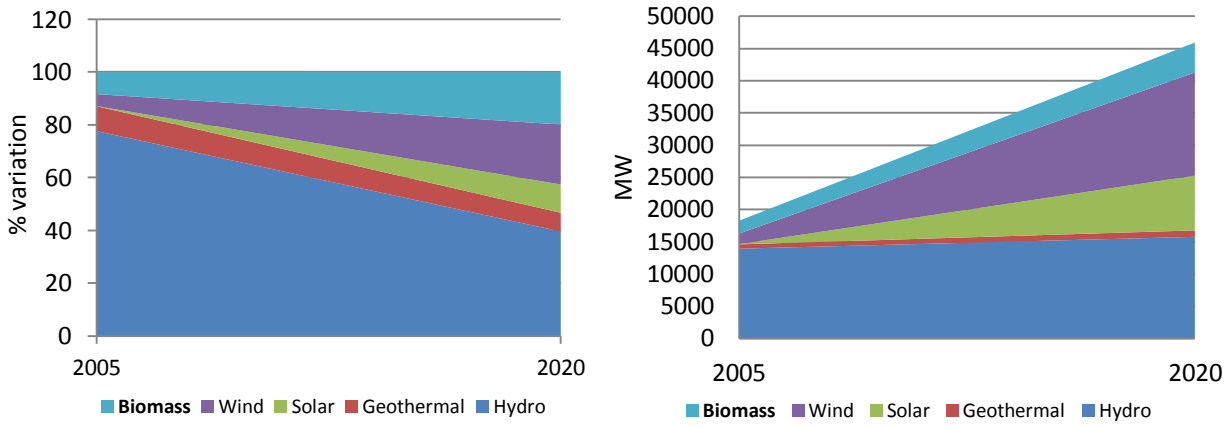
The Italian National Renewable Energy Action Plan (NREAP) has been approved by the Italian parliament in June 2010 in order to implement the Renewable Energy Directive of the EU. According to the plan, the target is to produce by 2020 the 17% of total energy consumption from RES, a contribution that in 2010 was 5.20%. Of this 17%, 16.20 are expected to come from domestic sources and the remaining 0.80% with transfer from other countries. In reaching this target, biomass, largely composed by woody biomass, has a strategic role as it is expected to cover about the 44% of the energy consumption from RES, for a total of 22.30 Mtoe.

One of the objectives of the NREAP is also to be able to redress in the medium-long term the energy mix balance of a country that at present depends largely on foreign energy supplies, over the 81.30% in 2013, one of the highest among the EU Member States (AEBIOM, 2013). In order to reach these targets, various policy measures and support-schemes (*i.e.* feeds-in-tariffs, green certificates, taxes) have been implemented to guarantee a sufficient level of remuneration for investment in RES and promote energy efficiency, which is considered a crucial factor to reach the 2020 targets.

The Italian renewable energy strategy and the contribution of bioenergy, according to the NREAP are showed in Figure 5 and Figure 6.

In Figure 5 is showed the share of electricity produced from RES in 2005 and as expected by 2020. The first figure shows the percentage contribution of the different sources to the total RES electricity share and the second the variation in absolute values (in MW). In 2005 biomass accounted for the 8.30% (1990 MW), the 6.20% if we consider only solid biomass. By 2020, the contribution of biomass to electricity production is expected to be the 19.82% (4650 MW), of which the 10.85% from solid biomass.

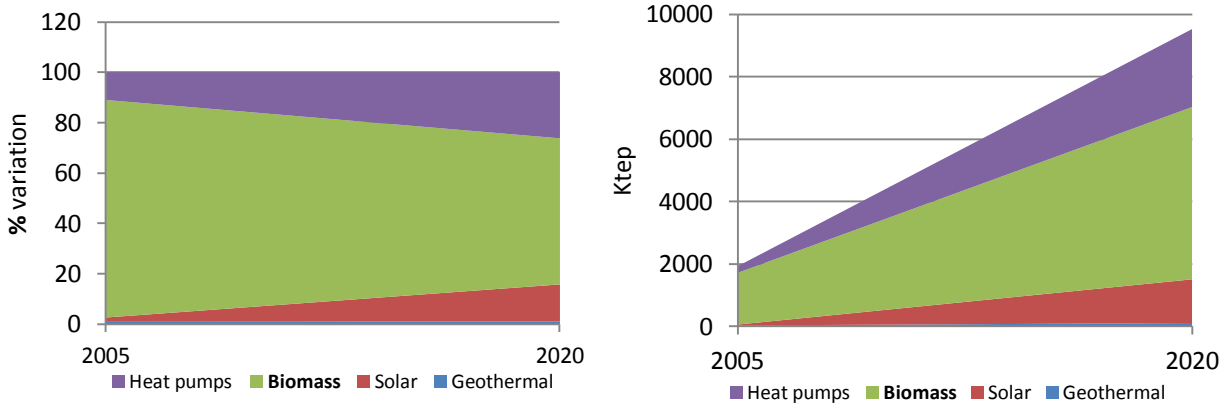
Figure 5: Electricity from RES according to the Italian NREAP



Source: NREAP

In Figure 6 the contribution of geothermal, solar, heat pumps and biomass to the heat production share from RES is showed.

Figure 6: Heat from RES according to the Italian NREAP



Source: NREAP

Again, in the first figure is shown the percentage contribution, while in the second the variations in absolute values (in Ktep). In 2005 the heat produced from biomass was the 86.34% of the total almost totally composed by solid biomass (84.99%). By 2020 the role of biomass for heat is expected to be the 57.98%, a relative decrease in relative terms, but a significant growth in absolute terms. Indeed the heat produced from biomass is expected to increase from the 1655 Ktep of 2005 to 5520 Ktep by 2020.

Among the different biomass sources, fuelwood (firewood, chips and pellets) is the first component, which alone accounts for around the 30% of primary energy production from RES (Ciccarese *et al.*, 2012). The main potentialities that are driving the growth of the wood-energy market in Italy can be summarized in:

- a large availability of woody biomass considering the current low utilization of the forest and also the large potential to develop SRF in several regions;
- The widespread distribution in the territory of forestry companies and cooperatives able to organize and operate on local value chains with positive socioeconomic effects;
- An economic advantage in producing heat with woody biomass, and the potential to develop district heating systems in small-medium towns.
- The opportunity to value the wastes and residues from the wood-processing industry, which are is particularly suffering the current economic crisis;

However, the wood-energy sector in Italy is considered to be not yet fully developed and thus the implementation of the NREAP with its ambitious targets will raise several important challenges in terms of market organization, policy regulation and public awareness (Scarlat *et al.*, 2013). Indeed, the lack of a stable and clear regulatory framework, a general lack of information and knowledge among market operators and the presence of relevant infrastructural barrier in terms of access to resources and operations, are considered to be the main limitation to the development of the wood-energy sector in Italy (Ciccarese *et al.*, 2012; ARSIA, 2009).

2.2.3 The problem of inconsistency of wood-energy data

As mentioned before, in several EU member states, including Italy, there are problems of lack and inconsistency of data regarding the wood-energy market (Steierer, 2007). A general consideration is that this is the result from the cross-sectorial character and the fragmentation of the wood-energy market itself. Indeed, as already mentioned, wood-energy data are related to

energy, agriculture and forestry and industry statistics, which are provided by different agencies and institution at international, regional or national level, often working with no coordination and with different focuses and definitions (EFSC, 2008). Furthermore, energy statistics are usually found in Tons Oil Equivalent, Watt and Joules with no information on the quantity of raw material used. These units of measurements are difficult to be translated in biomass quantities units (Cubic meters or Tons) without having information on the efficiency of the application or system used, and on the moisture content and chemical composition of the woodfuels. Sometimes, very generalized conversion factors can be used, compromising the quality of the data.

For what regards specifically the data on woody biomass production and consumption for energy, which is the focus of this thesis, we can identify several elements of complexity can create problems in terms of data collection (Pelkonen and Mustonen, 2014; ESFC, 2008; FAO, 2007). With regards to the structural characteristics of the EU market, these are related to:

- the information about self-consumption and on small forestry enterprises operating on local supply chains;
- the multiplicity of sources that have to be considered (from forest, outside forest, woody crops residues, wood-processing industry, post-consumption used wood etc.) which supply chain is often very complex;
- The multiplicity of end users of woody biomass (energy production vs. wood processing industry), which is often not consider by traditional statistics.

In the specific case of Italy, a reliable and coherent quantification of the wood-energy market has not been made. Indeed, inspite a considerable amount of available data and information, this is very uncertain and fragmented, and there are often relevant discrepancies between official data provided by ISTAT and estimates made by other studies (Pettenella and Ciccarese, 2009; Corona *et al.*, 2007; Magnani, 2005). For what concerns the wood harvesting, the main critical problems regard firstly the forest utilization data, especially in terms of fuelwood removals, which - as reported also by the FAO - are likely to much higher than what official statistics show (FAO, 2010). Secondly, the high number of micro and small forestry enterprises operating on local value chain, which is a structural characteristic of the Italian woody biomass market and which makes the market developments difficult to be monitored. On the consumption side, the main data gap is associated with the lack of information on household usage, which is a key variable that official statistics tends to underestimate (Alfano and Pignatelli, 2010; APAT-ARPA, 2007; APAT, 2003; Hellrigl, 2002). In recent years indeed, some studies stated that even the assumption relative to consumption levels of woody biomass made in the NREAP are

strongly underestimated (Negrin and Francescato, 2012; Pettenella and Andrighetto, 2011; Tomassetti, 2010).

As a consequence, the informative framework results to be clearly incomplete and thus a solid and coherent market estimation is lacking. This can be relevant limiting factor to an effective assessment and forecast of the role of woody biomass for energy as a RES in the national energy budget, also to be able to guarantee the sustainable growth of the sector and harvesting levels in the domestic supply of wood resources. This is then particularly important in front of the expected remarkable increase of the demand for wood-energy in Italy and Europe in the next years in the framework of the current 2020 targets and also in the perspective of a more long-term regulatory framework for RES promotion, as recently outlined by the European Commission (EC) with the Green Paper “A 2030 framework for climate and energy policies”.

3. Research methodology

In this chapter the research approach, sources of information and methodology adopted are described. In the research approach, the overall approach of the thesis and the methodologies used as for each of the three specific objectives are presented (3.1). In the following section the informative sources and the data collection and analysis methodologies used are explained singularly in details (3.2). At the end, a section is dedicated also to the limitations of the present work (3.3).

3.1 Research approach

In order to reach the overall objective the thesis has been built on a both qualitative and quantitatitive approach, using different sources of information and methodologies. With regard to the three specific objectives defined for the thesis, the approaches are here described.

Concerning the first specific objective – 1) to present an overview of the current state of the woody biomass for energy market in Italy based on a comprehensive review and consistency assessment of the statistical and literature sources and data available – the methodologies used have been:

- A comprehensive review of the available literature and statistical information, focusing mainly on national official and non-official sources and also in part on international and European sources (See sub-chapter 3.2.1 – Review of literature and statistical information).
- An assessment of the informative sources and data collected through the literature review with a consistency analysis based on experts' opinion. This has been done as part of the first Delphi survey questionnaire, in which a selected panel of experts had to express their opinion on a consistency scale for all the presented informative sources, providing a motivation and integrative comments (See sub-chapter 2.2.3 – Delphi survey questionnaire).

Regarding the second specific objective – 2) to contribute to a better estimation of the woody biomass for energy market in Italy, focusing firstly on households' consumptions based

on the analysis of the ISTAT “Survey on consumption by families”, and secondly on the internal production, based on experts’ opinion – two different methodologies have been used.

- For what concern a contribution for a better estimation of the consumption levels, focusing in the residential sector, the “Survey on consumption by families” organized by ISTAT has been analyzed. The analysis have been made focusing on the usage and expenditure for fuelwood at household level and the information gathered have been then used then to estimate the fuelwood consumption level at household level based on the expenditure (See sub-chapter 2.2.2 – ISTAT survey).
- Regarding the tentative estimation of the production levels based on experts’ opinion, focusing on the internal production, this was done through the conduction of Delphi survey questionnaires carried out in two different rounds (See sub-chapter 2.2.3 – Delphi survey questionnaire).

The third specific objective – 3) to present a comparative analysis of the current state of the woody biomass for energy market between Italy and Spain in order to assess the quality and availability of data in comparison with other countries – is based essentially on literature and statistical information collected thought the literature review. For this section of the work, the data collection and analysis has been done with the collaboration of a colleague from the Polytechnic University of Madrid, Mr. Adrian San Segundo Acosta (See sub-chapter 3.2.1 – Review of literature and statistical information).

3.2 Sources of information and methodology

As explained in the research approach, this study employed different sources of information, such as literature review data and information, the ”Survey on consumption by families” provided by ISTAT, and finally the Delphi survey questionnaires. The sources of information and methodologies used are presented in details in the following pages.

3.2.1 Review of literature and statistical information

A comprehensive review of the literature and statistical sources has been carried out at the beginning of the thesis work, in order to provide an overview of the current state of the Italian woody biomass for energy market, preparing the Delphi survey questionnaire for an expert

based consistency analysis, and finally to carry out the comparative analysis between Italy and Spain based on available information and data. The review has been done at three levels:

- A review of scientific articles and publications. Scopus and Science Direct databases were used for the purpose of this part of the literature review.
- An exhaustive collection of publications, reports and documents downloaded from the websites of the principal international agencies of the sector (*i.e.* FAOSTAT, Eurostat, and JWEE).
- A collection of data at national level based on official sources (ISTAT, other governmental agencies) and non-officials such as studies and surveys from agencies and associations of the wood-energy sector (*i.e.* ENAMA, ITABIA, AIEL, ENEA).

In addition, a review of literature has also been done for Spain, using the same approach as for Italy, thus collecting data from firstly official sources (Competent ministers, governmental agencies, national institute of statistics etc.) and from association operating in the sector (*i.e*. AVEBIOM).

Concerning the new estimation of the consumption levels of woody biomass in Italy made by AIEL, this is based on a study not yet published, but presented in a conference at the *Progetto Fuoco* event held in Verona in March 2014. The data were kindly provided by L. Bau and A. Paniz from AIEL for the purpose of this thesis.

3.2.2 The "Survey on consumption by families" by ISTAT

The "Survey on consumption by families" (*Indagine sui consumi delle famiglie*) by ISTAT has been analyzed in order to reach the second specific objective. The analysis of the survey permitted to gather new data and interesting insights concerning the number and level of expenditure for fuelwood at household level in Italy. Moreover, the information gather have been used to try to estimate the fuelwood consumption level at household level based on the expenditure.

The present ISTAT's survey is a large and important survey carried out by the Italian National Institute of Statistics (ISTAT) since 1968, but it has been completely renewed in 1996, so that the data series available in the current format is from 1997 to 2012. The survey provides deep information on the expenditure for goods and services, based on the so-called market basket, of household resident in Italy. Its aim is to describe households' living standard, cost of living and tendencies, but it is also used for official statistics at national level, such as the

calculation of the inflation at national level and the poverty level. The sample survey involves a large number of families which vary through the years (from 23,000 to 31,000 depending on the year), resident in around 480 Italian municipalities selected for the survey. The sampling is three-monthly based and is carried out for the four three-months of the year.

Data collection is committed to the municipalities, which are in charge of selecting the families to interview and supervise the survey procedures. The families are pulled out randomly from the municipality lists. 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 carried out by a municipality supervisor in order to integrate and clarify unclear information (ISTAT, 2012).

Our methodology in analyzing the questionnaire*:* Among the large amount of variables and information provided by the questionnaire, our target has been the expenditure for fuelwood and charcoal ("*legna da ardere e carbone*") at household level, registered for both first and second house. The survey data were received through request at the ISTAT web procedure and received in text (.DAT) format. The data were analyzed using the computer software Stata®, SPSS® and Microsoft Excel®.

In specific, out methodology to analyze the survey and make some elaborations can be divided in four steps:

- Extrapolating the data concerning the number of Italian household registering expenditure for fuelwood and charcoal, divided for the first and second house. In order to report the sample to the population, population survey coefficient provided by ISTAT in the survey material, have been used (Istat, 2012).
- Extrapolating the data on the total and average expenditure of household for fuelwood and charcoal. Also here the population survey coefficient has been used. In the survey these data on expenditure are register on monthly bases. We have converted the values from nominal to real values, in order to remove the effect of general price changes over the time series. We have done this using the inflation rate provided by ISTAT (See Table 3). Additionally, was necessary to convert the unit from Italian Lira (£) to Euros (€) for the years before 2002, using the standard conversion coefficient provided by the European Central Bank (ECB).

Table 3: Rate of inflation in Italy 1997-2012

Year	Inflation rate (%)
2012	1.011
2011	1.042
2010	1.070
2009	1.087
2008	1.095
2007	1.130
2006	1.150
2005	1.172
2004	1.192
2003	1.216
2002	1.246
2001	1.276
2000	1.311
1999	1.344
1998	1.365
1997	1.390

Source: ISTAT

- Overall comparing the data on fuelwood and charcoal with other fuel sources. The last interesting part of analysis was to compare the expenditure for fuelwood and charcoal with other energy sources included in the survey, such as expenditure for electricity, gas from the grid, gas in tanks and finally kerosene, gasoline and other liquid fuels.

Estimation of the household consumption based on the survey's information*:* Finally, we tried to estimate the quantity of fuelwood consumed at household level in Italy based on the expenditure information gathered in the ISTAT survey analysis. Specifically, to calculate the quantities consumed of fuelwood based on the relative expenditure we used a Consumer Price Index (CPI) for firewood. We have contacted several Italian Chambers of Commerce (*Camera di Commercio, Industria e Artigianato - CCIAA*), and the most complete information was provided by the Chamber of Commerce of Mantua, that we took and adjusted adding the Value Added Tax (VAT) (See Table 4).

Table 4: Consumer Price Index of firewood

Year	CPI (€)	CPI + VAT (€)
2012	154.50	185.40
2011	150.25	180.30
2010	149.38	179.25
2009	153.00	183.60
2008	147.25	176.70
2007	144.38	173.25
2006	146.25	175.50
2005	141.88	170.25
2004	138.38	166.05
2003	142.00	170.40
2002	142.00	170.40
2001	141.63	169.96
2000	141.63	169.96
1999	141.63	169.96
1998	143.10	171.72
1997	143.10	171.72

Source: Chamber of Commerce of Mantua

The spreadsheets with the calculations made in the analysis are presented in Annex 6.

3.2.3 Delphi survey questionnaires

A survey questionnaire using the Delphi method has been conducted to reach the first and second specific objectives. Specifically, for the carrying out the consistency analysis of the informative sources collected in the literature review and for reaching a new tentative estimation of the production levels of woody biomass for energy in Italy based on experts' opinion.

The Delphi survey method: The Delphi method is widely used survey technique in social sciences (Landeta, 2006; Gupta and Clarke, 1996). It is based on a structured process for collecting "knowledge" from a group of experts, by means of a series of questionnaires individually compiled with controlled opinion feedback. In specific, the Delphi method is based on two (or more) "rounds" of experts' involvement. It starts with the development a first round questionnaire and is distributed individually to an experts' panel, composed by a limited number of individuals, experts in the field of investigation. After receiving the responses, these are summarized and send back to the experts through a second round questionnaire, composed

usually of close-ended question aiming at clarify areas of agreement and disagreement among them and draw a final conclusion.

This method has been found useful for the purpose of this thesis for several reasons:

- it permits to involve a limited number of experts, enabling to focus on individuals' opinion and also to in generate consensus (or identify divergences of opinions), permitting to the experts, by means of the different "rounds" to review, re-evaluate and revise their opinions and estimates.
- It permits to deal with both qualitative and quantitative information and is well suited in situations where no historical data are available.
- It does not require face to face meetings, avoiding problems commonly associated with group interviews (i.e. persuasion, impact of oral facility). Moreover, face to face meeting would have been difficult to schedule considering the time available and the location of the experts involved.

The panel of experts: The expert panel was selected on the bases of the expertise of the individuals in the sector. Different experts were selected from universities, research institutes, associations of the sector and authorities. 14 experts have been contacted through email with a personalized letter, and we received a response from 10, thus with a respond rate of 71.50%. In the second round we received and analyzed only nine questionnaires responses out of ten sent before the deadline. The list of the panellists participating in the survey is presented in Table 5, all the expert agreed in the publications of their names except one, cited as "Expert 1".

Table 5: Panel of experts' composition

	Expert	Affiliation
1	*Anonimous*	CFS (National Forestry Service)
2	Raoul Romano	INEA (National Institute of Agricultural Economics)
3	Lorenzo Ciccarese	ISPRA (High Institute of Environmental Research)
4	Paolo Mori	*Compagnia delle Foreste* and *Sherwood*
5	Roberto Zanuttini	Politechnical University of Turin
6	Giuseppe Tomassetti	FIRE (Italian Federation for a Rational Use of Energy)
7	Annalisa Paniz	AIEL (Italian Association of Agroforestry Energy)
8	Bernardo Herrigl	University of Padua
9	Giuseppe Zimbalatti	University of Reggio Calabria
10	Franco Gottero	IPLA (Institute for Wood Plants and Environment

As mentioned, the survey has been carried out in two rounds and the two questionnaires were prepared and submitted in Italian language in a Microsoft Word® text file.

First round questionnaire: The first round questionnaire (Annex 1) was carried out between May and June 2014 and was structured in two separate sections:

1) **The informative sources consistency analysis:** the principal informative sources and data on the Italian woody biomass for energy market collected in the literature review have been categorized in four tables, dividing a) Import b) Residues, by-product and wastes from forest-based industry, c) Energy consumption, d) Internal production. This was made to facilitate the reading and to permit to the panellists to compare the data provided by the different sources. To the panellists was then asked to assess the consistency of the informative source, on the bases of the overall informative framework presented and individual knowledge, through a consistency scale from 1 to 4 (in order: "not reliable", "poorly reliable", "sufficiently reliable" and "very reliable"), including the possibility "I do not know", as in the example in Figure 7.

Figure 7: Example of consistency analysis compilation box

Import (in Mt/anno)						
Fonti	Cippato	Legna da ardere (e per carbone)	Residui legnosi	Pellets	Totale	**Affidabilità della fonte** *(1=Per niente; 2=Poco; 3=Abbastanza; 4=Molto)*
FAOSTAT (2012)	0,42	0,50	0,31	1,20	2,43	1 ☐; 2☐; 3☐; 4☐; Non so ☐
Eurostat (2012)		0,50		1,20	-	1 ☐; 2☐; 3☐; 4☐; Non so ☐
UNCOMTRADE (2012)	0,43	0,72	1,91		3,06	1 ☐; 2☐; 3☐; 4☐; Non so ☐

2) **Preliminary estimation of the production level:** In this second section, the panellists were asked to provide, on the bases of their knowledge and opinion, a preliminary estimation (or range of estimation) of the woody biomass for energy market in Italy, focusing on the internal production. For the purpose of the estimation, a simplified market flow chart was prepared, considering a) Import, b) Residues, by-product and wastes from forest-based industry, c) Energy consumption, d) Internal production. The estimation was subjected to a constrain, as in an analytic balance.

   In addition, as in the example in Figure 8, the experts were asked to provide an estimation of the four market section, focusing on the internal production, respecting the analytical balance constrain.

   Furthermore, some close-ended questions were associated to the estimation, in specific these were three:

- "How important are in your opinion the levels of non-registered fuelwood imported in the Italian market?"
- "How relevant is in your opinion the self-consumption at household level concerning the fuelwood consumption?"
- "How relevant is the fuelwood supplied in informal market channels?"

Figure 8: Example of the preliminary estimation compilation box

(A) Import	Esprima qui la sua **stima** (in Mt/anno):	Spieghi qui la sua **motivazione**: **Domanda 1**. Quali crede siano i livelli di importazione di biomasse legnose non registrate nel mercato italiano? Molto alti ☐; Abbastanza alti ☐; Non molto alti ☐; Irrilevanti☐; Non so ☐

Second round questionnaire. The second round questionnaire (Annex 2) was carried out o the last week of June and first week of July. It has been prepared after collecting and analyzing all the responses from the first round. The focus was only on the estimation of the production levels and market flows, thus much faster than the first. Respondents had the opportunity the review the first round outcome and revise their opinion. The outcome of the first round (mean, median and standard deviation) have been presented to the panellists, which were asked to review, re-evaluate and revise their opinion and estimates on the bases of the outcome presented and express and opinion of agreement or disagreement. As showed in the example in Figure 9, in case of disagreement, a new estimation was asked to be provided.

Figure 9: Example of compilation box for the second round Delphi questionnaire

Import	**Media**	**4,10 Mt**	Si ☐; No ☐	Nuova stima:

The responses to the first and second questionnaires are reported in Annex 3, Annex4 and Annex5.

3.3 Limitations

The present thesis work has several limitations that have to be taken into account. In general, due to the complexity of the investigated topic and the wide approach adopted, the single results of this work are meant to provide a contribution towards a better understanding of

the current informative framework consistency and on the estimation of the Italian wood-energy market, identifying important issues and areas for further more deep research.

Specifically in regards of the methodologies used, the most significant limitations are the following ones:

- Concerning the estimation of consumption level of fuelwood at household level based on the information gathered through the analysis of the "Survey on consumption by families" by ISTAT, an important assumption has been taken. For instance, in the variable "fuelwood and charcoal" registered in the survey and analyzed by us, no information are provided about sub-categories. In order to facilitate the calculations we considered only the CPI of "firewood", provided by the Chamber of Commerce of Mantua, however, we expect that also other woodfuels like pellets and briquettes have been included in the variable.
- Concerning the consistency analysis of the informative framework and the tentative estimation of the production levels based experts' opinion, this has been done involving a panel of experts trying to integrate different viewpoints (*i.e*. research, authorities, market operators), however, it has to be considered that representativeness of the experts' panel selected is very limited due to the limited number of individuals involved. Moreover it has to be remembered that the existence of a consensus on the out coming estimation does not necessarily mean its correctness and solidity. This is because as the panel of experts never meet, the results are built on a mix of individual's methodologies. The real significance of the experts' opinion based estimation is to identify the likely range values and the important issues related.
- The comparative analysis between Italy and Spain have been carried out in collaboration with a colleague from the Politechncal University of Madrid, however, due to the limited time available and the complexity in comparing plenty of material based on different conceptual approaches on the issue, the results presented are meant to be a preliminary overall comparison of the structural characteristics of the woody biomass for energy market in the two countries.

4. Review and assessment of the woody-energy market informative sources and data available

In this chapter the current state of the woody biomass for energy market in Italy is presented, with an exhaustive review and a consistency assessment of statistical and literature data available. In the first part (4.1) the informative framework is presented in four sections: internal production, import and trade, indirect supply from wood processing industry, and energy consumption. Special attention is then paid to present the new data reported in the Italian progress report under the Directive 2008/28/EC and a new estimation of the consumption levels of woody biomass for energy in Italy made by the Italian Agroforestry Energy Association (AIEL). In the second section (4.2) the result of the informative framework consistency analysis carried out with a panel of experts is presented and discussed.

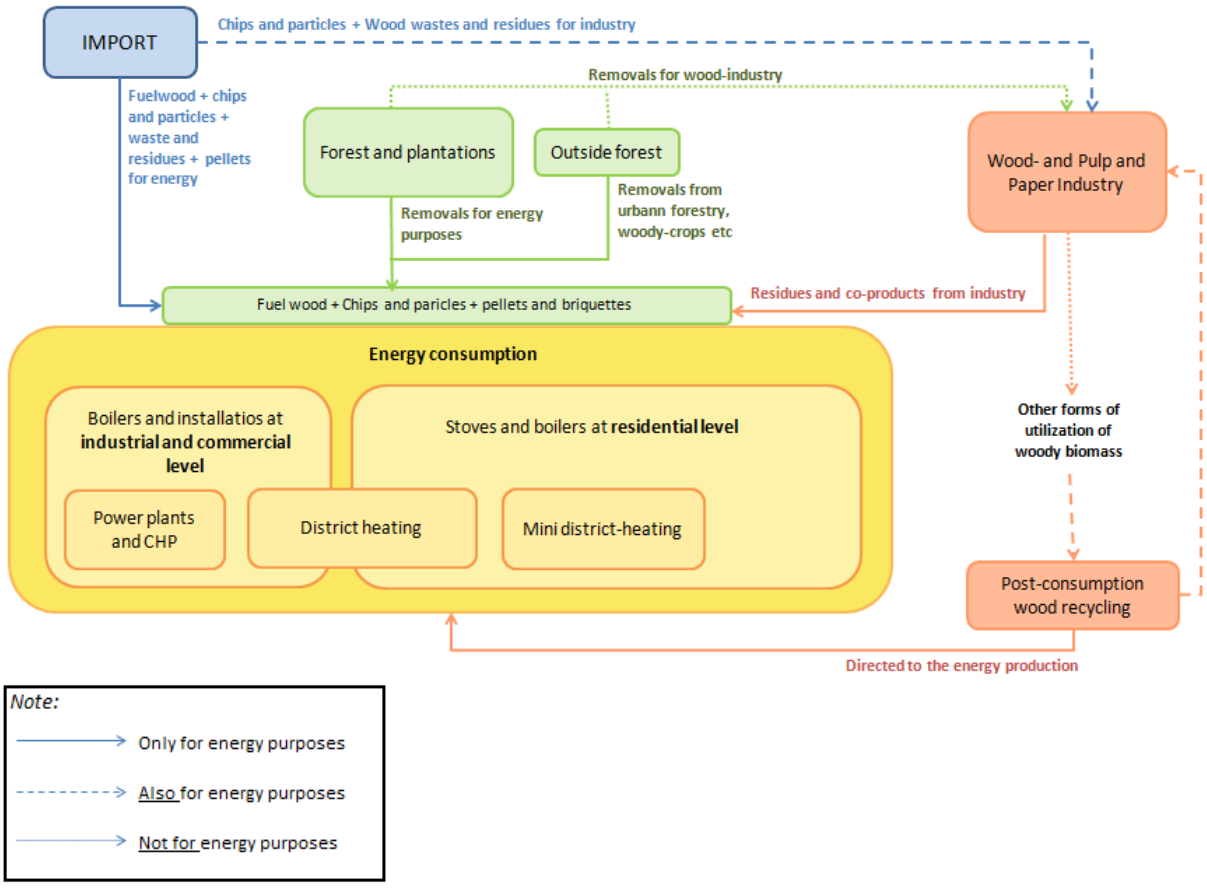
4.1 Overview of the woody biomass for energy market in Italy according to the informative sources available

As largely discussed in the background of the thesis, categorizing and quantifying the woody biomass for energy market is not an easy matter due to the variety of supply sources, the structure of the value chain and of the much diversified final users. .

In order to provide a general overview of the Italian woody biomass for energy market data, the market flow chart showed in Figure 10 (modified from Pettenella, 2009) has been followed. In the flow chart are identified all the main sources, supply chains and final users in all their complexity, identifying the flows of woody biomass only for energy purposes, partially for energy purposes and not for energy purposes. Different colours have been used to identify the different sections of the markets, dividing them in:

- Internal production from forest and outside forest areas *(*in green),
- Import *(*in blue*),*
- Indirect supply from wood-processing industry and post consumption used wood (in red*),*
- Consumption for energy purposes (in yellow).

Figure 10: Woody biomass for energy market flow chart



Source: modified from Pettenella, 2011

4.1.1 Internal production from forest and outside forest

In this section concerning to the internal production we will focus on the supply of woody biomass from forests, Short Rotation Forestry (SRF) and areas outside the forests.

A section is then also dedicated to the internal production of woodfuels, which in the particular cases of wood chips and pellets, is strongly connected to the availability of wastes and residue from the wood-processing industry, presented in the third section.

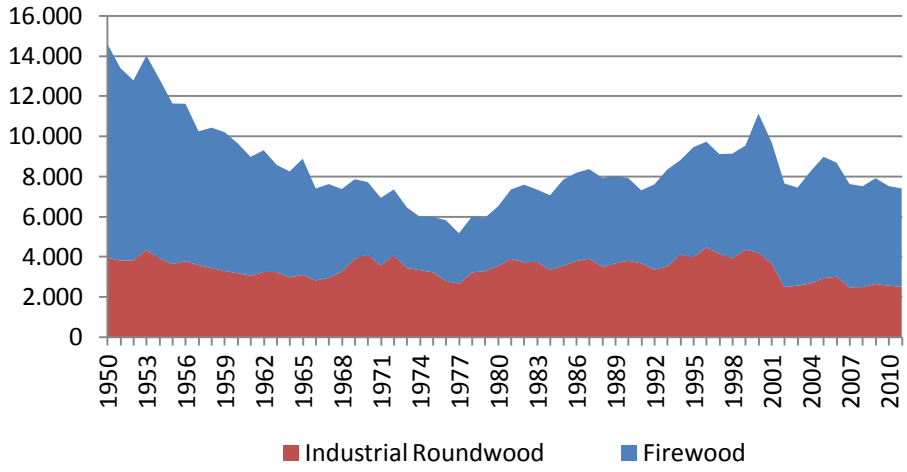
Woody biomass from forest: The forest area in Italy according to the last National Inventory of Forests and Carbon Stock of 2005 carried out by the National Forest Service (*Corpo Forestale dello Stato* - CFS) was 10,467,533 hectares, about the 36% of the national land. Of these, 8,759,200 ha (83.80%) are classified as “forest” and 1,708,330 ha as Other Wooded Land, resulting as the EU’s sixth country for forest area (after Sweden, Finland, Spain, France and Germany). At the time this thesis was written (February-July 2014) a third National Inventory

was under development and its publication expected to be during 2015. The forest area in Italy has been increasing significantly since after the Second World War, especially as a process of natural afforestation in consequence of the process of recolonization and abandonment of agricultural land in hilly and mountainous areas. The INFC estimated the total annual increment of the growing stock around 36,70 million cubic meters (4,30 million m^3 per hectare). Even the forest utilization has been very contained in the last decades, indeed according to the official data provided by ISTAT, the wood removals from forests results to be in these last years on average around one fifth of the annual growing stock (ISTAT, 2011).

In 2011, the last year in which ISTAT provided data about forest utilization, removals amounted to 7,346,650 cubic meters, of which about the 70% (5,084,591 m^3) of fuelwood (or wood for energy). Compared to EU average the removals from forest in Italy result slightly lower, in 2011 Italy removed from its forests on average 0.42 cubic meters per hectare, compared to the EU average of 0.52 m^3/ha. An interesting element to notice is that from the analysis of the forest utilization data since 1950 to nowadays, the trend of fuelwood removals showed a continuous increase in the last decades, returning to values similar to the ones of the early '60s, on contrary to the trend of removals for industrial timber, showing a process of de-specialization of timber production (Figure 11) (Favaro, 2011).

However, the forest utilization data available are very few, and moreover several studies in the last 20 years showed that the official data provided by ISTAT on fuelwood removals may be underestimated (Ciccarese *et al*, 2003; Magnani, 2005). Also recently, Corona *et al.* (2007) made a comparison between the surfaces cut at ground level of coppice in some central and southern regions as detected by high resolution satellite images and thus in the INFC of 2005 and those published by ISTAT, with a ration of estimates of 1.45. Also the FAO states in its Forest Resources Assessment country report, that "*due to the complexity and variability of administrative procedures in the 21 regional bodies responsible for cutting permits issuing and local statistics, could lead to underestimation* (…) *indeed fuelwood removals is likely to be much higher than what statistics show*" (FAO, 2010). In addition to the regional fragmentation of forest utilization statistics, it has also to be noticed that fuelwood is usually supplied in local value chains by micro and small forestry enterprises distributed in the national territory and moreover, also the self-consumption is still a very common practice. These two elements create problems in terms of data collection and market monitoring. Also the presence of informal activities in fuelwood harvesting is considered to be part of the so-called "historical illegality" in the Italian forestry sector (Pettenella *et al.*, 2012) and certainly causes problems to data collection.

Figure 11: Firewood and Industrial roundwood removals in Italy from 1950 to 2010



Source: Favaro, 2011

The data on forest removals (divided into fuelwood removals and timber for industry) according to different sources are presented in Table 6.

Table 6: Fuelwood and timber removals according to different sources

Source	Reference year	Removals from forest (m³)		
		Fuelwood	Timber for processing-industry	Tot.
ISTAT, 2011	2011	5.084,591	2,262,065	7,346,656
UNECE/FAO, 2013	2011	4,643,000	1,662,000	6,305,000
Gasparini e Tabacchi, 2011	2005			13,300,000
FAOSTAT, 2012	2012	5,388,000		

According to the official data provided by ISTAT, the fuelwood removals in 2011 amounted at 5,084,951m³, figure used also then by FAOSTAT, which in the following year, although ISTAT was not providing these data anymore, show a 5,388,000 m³ for fuelwood removals from Italian forests in 2012, thus with a 6% of increase compared to the previous year (FAOSTAT, 2012). Another informative source providing data concerning removals is the Joint Wood Energy Enquiry (JWEE), developed by UNECE Timber Section and FAO in collaboration with the IEA, as a new tool to collect in the scattered data on wood energy involving energy and forestry sectors operators and experts. This database gives a slight different figure of 4,643,000 m³ of fuelwood removals from forest (UNECE/FAO, 2013).

It is finally worth the figure provided by Gasparini and Tabacchi (2011) referring to the INFC of 2005 and reporting an aggregate value 13,300,000 m³ of total removals, resulting much higher of the one showed by the official ISTAT statistics.

Finally, no data are available for what concerns the supply of residues and wastes from silvicoltural activities (*i.e.* residues from harvest feeling, pruning and other small dimension by-products etc.), which represents on average the 20-25% of the total above ground mass in forest.

Supply from Short Rotation Forestry (SRF): Short Rotation Forestry (SFR) plantations are a typical supply source of woody biomass in several European countries, especially in central and northern Europe. They are mainly established in agro-forestry systems in agricultural lands using fast-growing species such as *Poplar* spp. or *Salix* spp.

In Italy SRF plantations, managed with rotation periods of 3-5 years, are mostly located in the Po valley, thus in Veneto, Emilia Romagna and Lombardy regions, providing wood chips to the power plants located in the North of Italy. However, despite the relevant economic support given to SRF in the last Common Agricultural Policy (CAP), this sector has shown some difficulties to take off and so far it did not become so spread in comparison to other EU countries, although an increase between 3,000 to 5,000 ha in the area dedicated to SRF is foreseen for the future (Ciccarese *et al.*, 2012).

In terms of quantities of woody biomass deriving from these plantations, specific data does not exist at the moment at national level.

Supply from outside forest areas: The last important category to be considered is the outside forest land. This includes woody biomass from urban forestry, such as from the management of urban parks and gardens, roadside trees and other green areas in urban context, and the woody biomass from woody crops like fruits orchards.

As shown in Table 7, just two sources give statistics concerning fuelwood removals from outside forest area in Italy. The first is ISTAT, which recorded for 2011 303, 897 m³ of fuelwood removals from outside forest areas. The other is the JWEE, which reported the quantity of fuelwood from outside forest to be even 15 million m³ (UNECE/FAO, 2013).

Table 7: Removals from outside forest according to different sources

Source	Reference year	Removals from outside forest (m^3)		
		Fuelwood	Timber for processing-industry	Tot.
ISTAT, 2011	2011	303,897	93,910	397,807
UNECE/FAO, 2013	2011	15,000,000	0	15,000,000

In addition, residues and by-products from farm products processing, like hazel and walnut shells and olive stones, which are used for energy production, should be recorded. An example is the woody residues from the winter time pruning of the vineyards. The Italian Agency for New Technologies for Energy and Environment (ENEA) carried out a study on this type of biomass, showing that there is a large amount of agricultural residues available but its utilization is difficult, mainly due to logistic problems in collection, as the raw material comes from high number of small and micro farms, widespread on the territory and difficult to reach. Thus, the residues from agro-industrial sectors are often used for energy in the same sites where they are produced.

Concerning the residues from urban forestry activities, despite the large potential showed (ITABIA, 2008), it has also to be said that at the moment there is a law that does not permit the use of these residues as biomass for energy (Legislative Decree 3/4/2006 no. 152, called also *Testo Unico Ambientale*). Several studies have been made in the last years to estimate the woody biomass potentially available from urban forestry in terms of woody residues and by products from pruning and ordinary management activities. The Italian Federation of Renewable Energy Producers (FIPER), in a study carried out recently, estimated the potential woody biomass available from this sector to be between 3 and 4 million cubic meters (FIPER, 2013). Another interesting study carried out by AIEL (2008), estimates the woody biomass available from trees outside forest in the Veneto region. The results are showed in Table 8.

Table 8: Estimation of the production (t/ha) of woody biomass from outside forest in the Veneto Region

	High forest	Coppices	Roadside trees	Urban gardens
Thinning	1.8 - 3			0.5-0.8
Pruning				0.10-0.15
Fuelwood removals		10.00	20-25	

Source: AIEL, 2008

Internal production of woodfuels. Some final interesting data to show are the ones concerning woodfuels production in Italy. However, in the specific case of wood chips and pellets it has to

be considered the link with the wood-processing industries, especially in the case of pellets which are produced from residues deriving from wood processing activities. Moreover, it has also to be kept in mind that multiple end use of wood chips, for the energy production as well as for wood-based panels' production.

International and regional agencies such as FAOSTAT, UNECE and Eurostat, and two Italian informative sources, provide data on woodfuels production (See Table 9).

Table 9: Woodfuels production according to different sources

Source	Reference year	Production	
		Chips and particles (m^3)	Pellets (t)
FAOSTAT, 2012	2012	1,096000	300,000
UNECE, 2013	2012	1,096,000	
Antonini and Francescato, 2011	2011	800,000	
Eurostat, 2013	2011		816,000
AIEL, 2009	2009		600,000

Concerning the production of wood chips, FAOSTAT and UNECE provide the same figures, 1,096,000 m^3 for wood chips (recorded as "chips and particles"), taking 2012 as reference year (FAOSTAT, 2012; UNECE, 2013).

According to Negrin and Francescato (2014), the wood chips market has the characteristics of a new market, with very diverse production costs depending on the local context and highly diversified users with different "willingness to pay". In a study conducted by Antonini and Francescato (2010), an internal production of 800,000 tons has been estimated, mostly from wood processing industries (see Chapter 4.1.3).

Concerning pellets production more discrepancies are present. FAOSTAT registers for 2012 a production of 300 thousand tons of pellets (FAOSTAT, 2012) while Eurostat, with 2011 as reference year, 816 thousand tons (Eurostat, 2013). A recent study carried out AIEL in 2011 showed that Italy was the first pellet market in the EU, with a consumption of more than 1.70 million tons, of which 600 thousand tons from internal production coming from 85 small and medium pellet manufacturers, mostly using sawmills residues as raw material (AIEL, 2011).

4.1.2 Import and trade

The import of woody biomass from foreign countries plays a very important role in Italy. Italy is indeed among the firsts importers of wood pellet and firewood in the world (Pettenella, 2011).

Statistics on import and trade are provided by international trade statistics database such as FAOSTAT and UN COMTRADE and regional agencies such as Eurostat and UNECE. The data provided by the different sources are presented in Table 10.

Table 10: Import of woodfuels according to different sources

Source	Reference year	Import			
		Chips (m³)	Fuelwood (and charcoal) (m³)	Pellets (t)	Waste and residues (m³)
FAOSTAT, 2012	2012	844,000	991,463	1,197,000	623,000
Eurostat, 2013	2012		991,460	1,197,000	
UNECE, 2012	2012	844,00	991,463		96,000
UNCOMTRADE, 2012	2012	434,679.(t)	720,448.(t)		1,900,710.(t)

FAOSTAT (2012) report an import of 844,000 m³ of chips and particles, an import of 991,460 m³ of fuelwood, 623,000 m³ of wood waste and residues and finally 1,197,000 tones of pellets. These figures are then used also by Eurostat and UNECE, with the only difference for what concerns wood wastes and residues where the UNECE data banks provide a 96,000 m³ of import. However, the discrepancy is caused by the different definition adopted by the two sources.

Different from the ones already presented, are the data provided by UNCOMTRADE (2012), which presents the import quantities in tons (instead cubic meters as the others). It reports 434,679 tons of wood chips, 720,488 tons of fuelwood and finally 1,900,710 tons of wood and wood waste (including sawdust and scrap).

Besides these sources, some studies on the woody biomass for energy market in Italy presents some consideration about the import, for example Pettenella (2009), states that considering the estimations made by previous studies, an import of about one million tons of wood chips is reasonable, considering the demand from the large scale biomass plants. The main partners are especially Balkans countries, Romania and Bulgaria for chips, and Austria, Germany and Slovenia for pellets. Concerning pellets, AIEL shows in a recent estimation of the consumption levels of woody biomass in Italy (See Chapter 4.1.5) that the consumption of pellets amount at around 3.30 million tons, of which only 20% produced in Italy. Thus, considering this result, we would obtain an import of more than 2.6 million tons.

To conclude, it has to be considered the multiple end uses of imported wood chips and of wood residues and wastes. In particular, concerning the wood chips import an important role is considered to be played by the particle board industry (Ciccarese *et al.*, 2012). In the case of

FAOSTAT, the import of raw material directed to the pulp and paper industry is excluded from the figures presented, as it is recorded under a different category (“pulpwood”).

Export: For what regards the export, this is very low, not relevant if compared to the import levels. Statistics from FAOSTAT and UNECE are showed in Table 11.

Table 11: Export of woodfuels according to different sources

Source	Reference year	Export			
		Chips (m^3)	Woodfuels (and charcoal) (m^3)	Pellets (t)	Waste and residues (m^3)
FAOSTAT, 2012	2012	2,000	3,060	5,000	14,516
UNECE, 2012	2012	2,000	3,000		5,000

In 2012 FAOSTAT register an export of 2,000 cubic meters of chips and particles, 3,060 of firewood, 14,516 of wood waste and residues, and finally 5,000 tons of pellets (FAOSTAT, 2012). UNECE provide different data only concerning the waste and residues, again for a definition difference.

It can be concluded that all the internal production is consumed in Italy, with no relevant export flows.

4.1.3 Indirect supply from industry and post consumption used wood

The indirect supply from the wood processing industry, pulp and paper industry and the post-consumption used wood is probably the most critical section of the market to identify and quantify, and this is due, as showed in the flow chart, to the complex logistics of the value chain.

No official data exists on the issue. FAOSTAT registers for 2012 a production of 904,000 tons of “wood waste and residues”, meaning to “the volume of roundwood that is left over after the production of forest products in the forest processing industry (*i.e.* forest processing residues) and that has not been reduced to chips or particles”.

Some studies have been then carried out in the last years in order to try to estimate the quantity of residuals, by products and wastes potentially used for energy production from the industry. These are shows in Table 12.

Table 12: Indirect supply of woody biomass from industry according to different sources

Sources	Residues from wood-processing industry (t)	Residues from pulp and paper industry (t)	Post-consumption used wood (t)
ITABIA (2008)	4,200,000	300,000	
ENAMA (2011)	1,800,000	150,000	4,000,000
FAOSTAT (2012)	904,000		

The study conducted by the Italian Biomass Association (ITABIA) refers in general to the woody biomass in terms of residues and wastes produced by the wood-processing industry and pulp and paper industry. For the wood-processing industry it estimates a quantity of 4.20 million tons of residues and wastes, while 300 thousand tons from the pulp and paper industry (ITABIA). The other important study has been conducted by the National Agency for Mechanization in Agriculture (ENAMA) considering only the residues and wastes potentially available for energy production. From its estimation, results that 1.80 million tons are potentially available from the wood-processing industry and 150 thousand tons from the pulp and paper. In addition, ENAMA estimates 4 million tons of post-consumption used wood potentially available for energy (ENAMA, 2011).

As an example, the *Fantoni* group, n very important Italian company in the sector or MDF and chipboard panels and more in general wooden office furniture, states in its 2013 report an amount of residues and wastes employed for energy and panel productions of 300 thousand tons deriving from the wood processing, and 200 thousand tons of recycled post consumption used wood (Fantoni, 2013).

Concerning post consumption used wood, the Italian consortium for the recycling of wood packaging material (Rilegno) shows interesting figures in its 2013 market balance report (Rilegno, 2013). In 2013, the consortium, which is composed by 2275 companies located in all Italy, recycled more than 2 million tons of wood packing material (2,163 thousand tons), of which the 65% composed by pallets. Of this amount, 80 thousand tons are used for energy production.

4.1.4 Consumption for energy production

As showed in the flow chart at the beginning of the chapter, woody biomass is used for energy production in different appliances and systems and with different conversion methods. In terms of final users we can distinguish between two categories:

- the residential sector (stoves, fireplaces and boilers mainly for heating);

- The industrial and commercial heat and power sector, composed by boilers at industrial level, biomass power plants, CHP and district heating systems.

Consumption in the residential sector: In terms of final users, woody biomass is used in Italy mainly in the residential sector, to which the Italian regulatory framework has given notable development. Thus, it is used mainly in small households' appliances for heating such as stoves, fireplaces, and small boilers, using firewood and pellets. In particular, pellets represent a well consolidated market in Italy. Indeed, despite the consumption of firewood is very high, the tendency is to use more processed woodfuels, especially pellets, which can be burned in much more efficient appliances, which are more and more available in the Italian market.

The last available official data from ISTAT was published in 2010, reporting a consumption of fuelwood in Italy ("*legna da ardere e fasciame*") of 37,820.00 thousand quintals (3.78 million tons) (ISTAT, 2010). Also the JWEE (2013) provides a figure about woody biomass consumption in the residential sector, amounting at 11.90 million tons, which assuming a conversion factor of 1 m^3=0.5 t (Mantau *et al.*, 2010) results in almost 24 million cubic meters, extremely far from the ISTAT figure. In addition, in the National Energy Balance (BEN) of 2012, is reported a data on woody biomass consumption in the residential sector of 14.33 million tons, including firewood, pellets and charcoal (BEN, 2012).

However, several studies published in the last 25 years, shows that the data on household fuelwood consumption tends to be undestimated by official statistics. In Table 13 are reported the main studies or survey to estimate the consumption of fuelwood at household level. Some insights and methodologies are here presented in specific:

- The survey of the *Istituto di Sociologia Rurale* (Institute of Rural Sociology) in 1998 was focused only in rural households located in hilly and mountainous areas and estimated a consumption of fuelwood of 17..80 million tons/year.
- The ENEA survey in 1999 (Gerardi and Perrella, 1999) on the biomass (all types of biomass) consumption at household level was conducted at national scale on a 6.000 household sample. It resulted that around the 22% of Italian households were using biomass for energy, mainly in Sardinia. Trentino/South Tyrol and Abruzzo. The final estimation was of 14,680,000 tons/year, of which 47% from self-consumption.
- A regional based survey has been made in Lombardy by the Lombardy Environmental Agency in the winter 2003/04. The survey was based on almost 33 thousand surveys sent to secondary school students, not taking into consideration the areas. It resulted that 25% of the families were using wood, resulting in a total of

1.9 million tons/year. Marazzi *et al.* (2006) on the bases of this survey, estimated a consumption level at national scale of 22.6 million tons/year.

- IPLA, a regional agency of the Piedmont region, conducted in 2006 a survey on a sample of 3,000 families located in towns with less than 10,000 inhabitants. The results showed that around the 42% of the residents in small towns were using fuelwood for domestic heating, resulting in a consumption level of 3 million cubic meters (1.5 Mt). The interesting element provided is that 67% of this results from self-consumption.
- The Regional Agency for Environmental Protection (ARPA) estimate is based on a survey conducted at national level to gather data and information on fuelwood consumption. The sample was composed of 5,000 households' representative of the Italian population. It resulted in an estimation of 19 million tons/year of fuelwood consumed. Moreover, that the 20% of the households use fuelwood at least four times in a year, of which around the 72% in traditional low efficient applications. The large part the users are located in hilly and mountainous areas.
- Antonini and Francescato (2010) in an analysis of the woody biomass for energy market estimated a consumption level of 21 million tons at household level, of which 1.20 million tons of pellets and 900 thousand tons of wood chips.

Table 13: Estimation of household fuelwood consumption according to different sources

Source	Reference area	Year	Estimation
Istituto di Sociologia Rurale	Italy *(only households in mountainous and hilly areas)*	1998	17.80 Mt
ENEA	Italy	1999	14.60 Mt
FLA Lombardy	Lombardy Region	2003/04	1.90 Mt
IPLA Piedmont	Piedmont Region *(only household in towns with less than 10.000 inhabitants)*	2006	3 Mm^3 (1.5 Mt)
APAT-ARPA	Italy	2006	19 Mt
Marazzi et al., 2006	Italy *(based on results of FLA for Lombardy region)*	2003/04	22.60 Mt
Antonini e Francescato, 2010	Italy	2010	21 Mt (including pellets)

As mentioned at the beginning, the data on household consumption of fuelwood are difficult to be intercepted and thus are often underestimated by official statistics; this is a typical situation in many industrialized countries (Steierer, 2007).

In Italy, as showed, the level of information concerning households' consumption is very low and presents relevant discrepancies. This statistical uncertainty is mainly related to some structural characteristics of the Italian wood-energy market. In particular the presence of micro and small forestry enterprises supplying fuelwood to household in local chains, difficult to be monitored. Moreover, the role of "informal" market channels and self-consumption (as highlighted in some of the studies mentioned) is considered to be relevant. In more recent years, some studies stated that, due to the lack of a solid knowledge on household consumption, even the assumption made in the NREAP results strongly underestimated (Pettenella and Andrighetto, 2011).

Industrial and commercial heat and power: Large scale installations such as biomass-based power plants and District Heating Systems (DHS) are present in Italy, but the sector is not yet fully developed (Scarlat *et al*,. 2013). Specifically, an overview is here presented:

- *Power plants*: Power plants using biomass in Italy, according to the national authority *Gestore Servizi Energetici* (GSE), were 78 in 2010, with a total installed power around 1,440 MWe, but further 122 plants resulted to be in project or under construction, with a total installed power projected at 785 MWe. In 2009 GSE reported a consumption of 1.8 million tons of chips per year (GSE, 2009).
- *District heating systems and CHP:* the sector is still very small in Italy, and the DH systems are mainly located in Northern regions, in particular Trentino-South Tyrol, Piedmont and Lombardy. According to Antonini and Francescato (2010) 86 DHS are installed in Italy with a potential of 400 MWt, resulting in a consumption of about 407 thousand tones/year of chips. Of these, 18 have CHP applications (for a total of 13.50 MWe).
- *Mini district heating systems (< 1MW):* The only data available on mini district heating systems is again by the estimation of Antonini and Francescato (2010), which with regards to only five regions (Piedmont, Trentino/South Tyrol, Veneto, Friuli Venezia Giulia and Tuscany) reported a consumption of about 380 thousand tons/year of wood chips.

Table 14: DHS in Italy

Regions/Provinces	No.	MWt	Chips and particles (t/y)
South Tyrol (AP)	57	181	223,810
Trentino (AP)	4	22.4	18,998
Lombardy	7	111.4	94,690
Piedmont	6	33.3	28,305
Aosta Valley	3	17.6	14,960
Emilia Romagna	1	6	5,100
Veneto	2	11.2	9,520
Friuli Venezia Giulia	3	6.2	5,245
Liguria	2	1.9	1,615
Tuscany	1	6.5	5,525
Total	86	398.4	407,767

Source: Antonini and Francescato, 2010

4.1.5 The data in the Italian Progress Reports 2013 under the Directive 2009/28/EC

In order to monitor the developments towards the 2020s renewable energy targets set by the EU Directive 2008/28/EC, the European Commission (EC) requires the Member States to prepare periodically a report presenting their progresses and compliance with the measures set out at EU level, named the "Member States Progress Report under the Directive 2009/28/EC". The present report, published in 2013, is the second report (the first was in 2011). The information provided in the reports regards policy developments, energy production and also resources employed for energy production. The data, presented in compliance to the Eurostat harmonized methodology, are provided the national competent authority, and thus to be considered as official data. Indeed, this is also used by the EC of measure the consistency and homogeneity of the energy statistics in the Member states.

For the purpose of the thesis, it is particularly interesting to present the data concerning the availability and use of biomass resources for energy purpose in 2011 and 2012. The table data are reported in Table 15:

- Concerning the internal production ("amount of domestic raw material"), the report show a direct supply of woody biomass from forest and other wooded land for energy generation of 8,350,500 tons in 2012. Again if we assume a conversion factor of 1 m=0,5 t (Mantau *et al.*, 2010) we obtain 16,701,000 m^3 of supply from forest, which

much higher than the last official ISTAT data of 5,084,591 m³ of fuelwood removals from forest (ISTAT, 2011).

- The indirect supply ("indirect supply of residues and co-products from wood industry etc."), including also pellet production, is showed to amount at 2,209,998 tons in 2012. Finally biomass from energy crops and SRF of 2,861,961 tons, including also other solid biomass (from grasses etc.) but it includes also the woody biomass from SRF, mentioned to amount at 7,000 hectares in 2012.
- Concerning the import from EU, this is showed to be 1,220,713 tons in 2012 of forest woody biomass and 1,654,829 tons/year of indirect woody biomass from industry. Less relevant in this case are the import of biomass from energy crops and the import from non EU countries.

Table 15: Biomass supply according to the Member State progress report under Directive 2009/28/EC

	Amount of domestic raw material (*)		*Primary energy in domestic raw material (ktoe)*		*Amount of imported raw material from EU (*)*		*Primary energy in amount of imported raw material from EU (ktoe)*		*Amount of imported raw material from non EU(*)*		*Primary energy in amount of imported raw material from non EU (ktoe)*	
	2011	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
Biomass supply for heating and electricity:												
Direct supply of wood biomass from forests and other wooded land energy generation (fellings etc.)**	7,735,474	8,350,500	2,679	2,892	1,386,656	1,220,713	480	423	32,532	15,978	11	6
Indirect supply of wood biomass (residues and co-products from wood industry etc.)**	2,064,224	2,209,998	772	835	1,798,286	1,654,829	690	653	128,238	149,867	54	63
Energy crops (grasses, etc.) and short rotation trees (please specify)	2,539,766	2,861,961	610	684	57,352	114,433	51	104	490,391	504,123	437	460
Agricultural by-products / processed residues and fishery by-products **	2,292,331	2,199,522	547	544	-	-	-	-	-	-	-	-
Biomass from waste (municipal, industrial etc.) **	5,204,662	5,379,550	1,354	1,341	-	-	-	-	-	-	-	-
Others (please specify)	-	-	-	-	-	-	-	-	-	-	-	-

(*) Data in tons/year
(**) Including pellets

4.1.6 A new estimation of the consumption levels in Italy based on the installed capacity (AIEL)

The Italian Agroforestry Energy Association (AIEL) presented this year a new estimation of the consumption levels of woody biomass for energy in Italy.

The methodology used by AIEL was to estimate the quantity of woody biomass consumed for energy purposes based on the energy production capacity and consequent demand for woodfuels from the installed appliances in Italy. The appliances have been divided in three groups:

- Appliances for residential heating (stoves, fireplaces etc.);
- Boilers at household, commercial and industrial level;
- Large scale power plants, CHP and DH systems.

Consumption in appliances for residential heating. These informations are based on the data provided by *SWG Ltd*, a company specialized in surveys in Italy. According to SWG, in Italy in 2013 resulted installed 1.90 million pellets-burning appliances and 7.90 million fuelwood-burning ones, divided into stoves and fireplaces. The elements that have been taken into account in the estimation are:

- Usage level: different for primary residences and second houses and according to the altitudinal range (plain, hills, mountains);
- Average power of 8 kW;
- Average efficiency between 70% and 90%;
- Hours of functioning between 1000 and 1800 yearly (primary residence);
- Lower Calorific Value (LCV) of 4.60 MWh/t for pellets and 3.98 MWh/t for fuelwood.

The result of the estimation shows a consumption of 2.40 million tons of pellets for residential heating and 16.10 million tons of firewood (See Table 16).

Table 16: Consumptions for residential heating

Pellets burning appliances (t/y)		Firewood appliances (t/y)	
Stoves	2,090,000	Stoves	5,266,000
Fireplaces	210,000	Closed fireplaces	5,073,000
Kitchen stoves	70,000	Kitchen stoves	1,722,000
TOT.	2,400,000	Open fireplaces	4,034,999
		TOT	16,100,000

Data: AIEL

Consumption from boilers at residential, commercial and industrial level. The second category of appliances were boilers at residential level (< 35 kW) and at commercial and industrial level (> 35 kW). In Italy resulted installed in 2013:

- At household level 199,000 pellet-burning boilers, 596,000 firewood-burning boilers and 1,500 chips-burning boilers;
- At commercial and industrial level, 2,470 pellet-burning boilers, 7,400 firewood-burning ones and 2,260 chips-burning.

The parameters used for the estimation were:

- A different average heating capacity set for different categories;
- An average efficiency of 90%;
- Hours of utilization between 1500 and 1800 yearly;
- LCV of 4.6 MWh/t for pellets, 3.98 for firewood and 3.4 for chips.

The results show a consumption of 0.90 Mt/year of pellets, 3.20 Mt/y of firewood and 1 Mt/y of chips (See Table 17).

Table 17: Woodfuels consumption according to the end user

	Residential boilers	Commercial and ind. boilers	Industrial boilers	Tot.
Pellets (t/y)	796,500	106,000	14,350	917,000
Firewood (t/y)	2,980,300	211,500	0	3,192,000
Chips (t/y)	10,500	830,500	176,000	1,017,000

Data: AIEL

Consumption from large scale power plants, CHP and district heating systems. Concerning the large scale installations in Italy, these are consuming mostly wood chips, and have been divided into:

- Power plants and CHP;
- District heating systems > 1MW;
- District heating systems < 1MW.

Concerning biomass-based power plants and CHP, there are 483 in Italy. The parameters assumed are:

- A capacity of 1,584 MWe;
- 25% efficiency;
- A primary energy production of 3,900 MWh ;

- Filled at 60% with solid biomass;

The District Heating Systems >1MW are 95 in Italy, and the calculations have been made considering;

- Capacity of 343 MWt;
- 80% efficiency;
- A primary energy production of 1,156,000 MWh.

Finally the district heating < 1 MW are 87, assuming as parameters:

- Capacity of 26 MWt;
- 80% efficiency;
- Primary energy 38,600 MWh.

From the analysis, it results a consumption of wood chips 3,317,500 tons/yeas of chips from power plants (and CHP), 411,000 tons/year in DH systems and 12,500 tons/year in mini district heating. The total wood chips consumption from large scale installations is thus 3.3 million tons/year, as showed in Table 18.

Table 18: Chips consumption in large scale plants

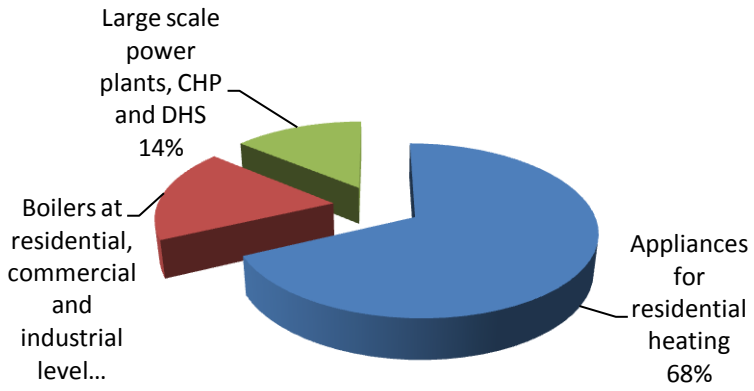
Large scale plants (t/y)	
Power and CHP	3,317,500
District heating > 1MWh	411,000
District heating < 1MWh	12,500
Tot. chips consumption	3,300,000

Data: AIEL

Overall estimation of the woody biomass for energy consumption and discussion. From the estimation it result a total the consumption of woody biomass for energy in Italy of 27.3 million tons per year, among 19.3 Mt/y of firewood, 4.7 Mt/y of chips and 3.3 Mt/y of pellets.

As showed in *Figure 12* the major role is played by the appliances for residential heating (68%), followed by the boilers at residential, commercial and industrial level (18%) and finally the large scale installations (14%).

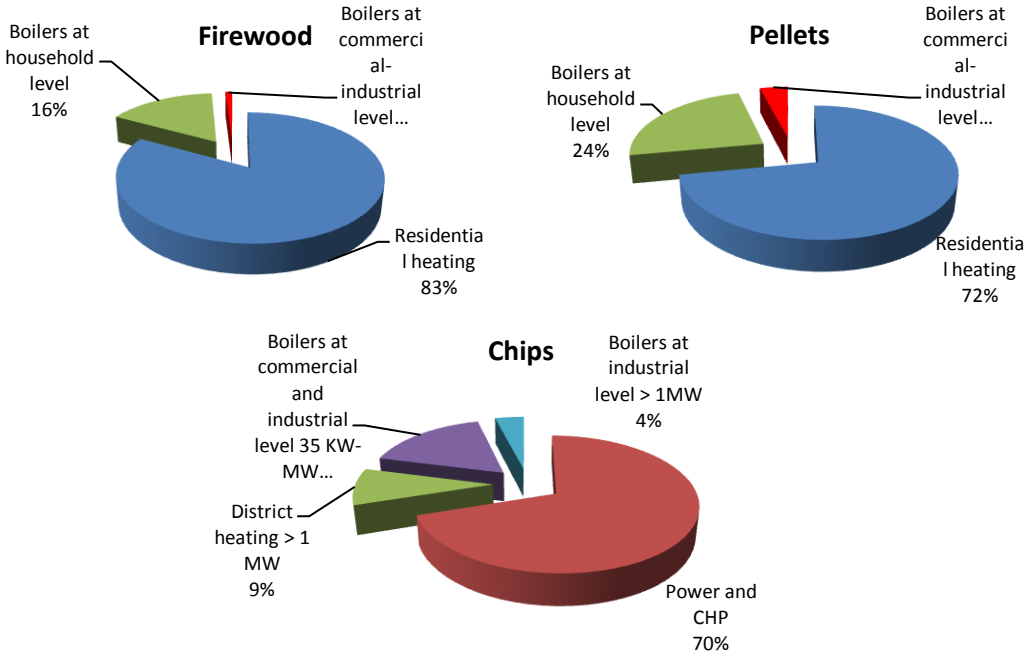
Figure 12: Estimation of woody biomass consumption by final users



Data: AIEL

The consumption estimated, divided by firewood, pellets and wood chips for the different end users are presented in Figure 13.

Figure 13: Estimation of the firewood, pellets and chips consumption by final user



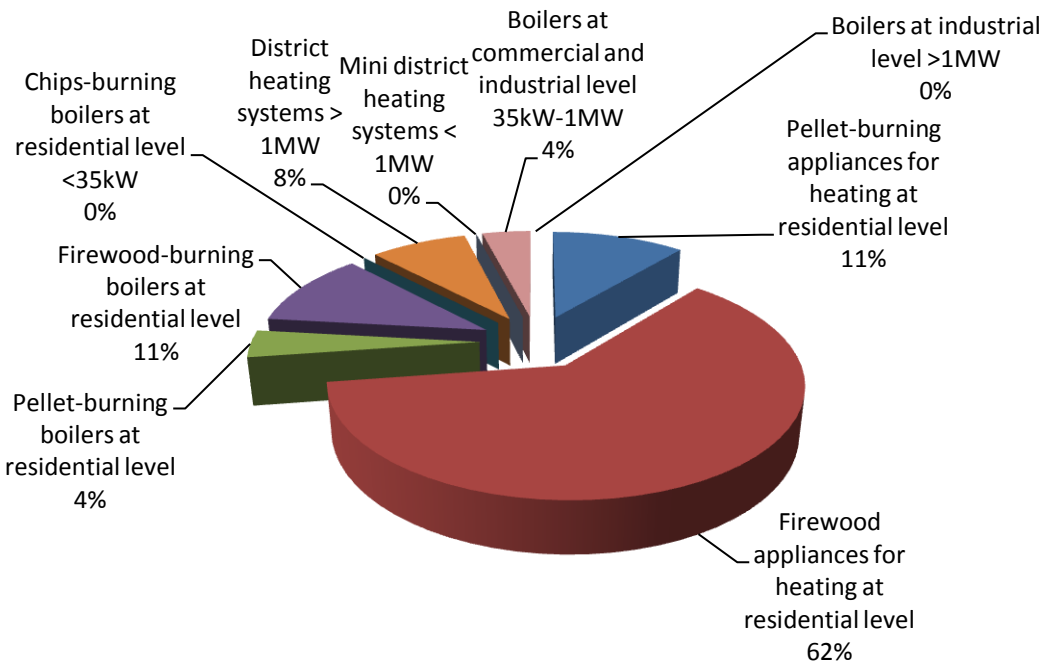
Data: AIEL

It can be observed that for what concern firewood almost the totality is consumed at household level (99%). The same is for pellets, although here also the boilers at commercial and industrial levels are significant (4%). Different is for wood chips, which enters a totally different

market, 70% power plants and CHP, 9% in DHS and the rest in boilers at commercial and industrial level.

In the last figure (Figure 14) the consumption by final users (grouped by sector and capacity) is showed.

Figure 14: Overall estimation of the woody biomass for energy consumption by final users



Data: AIEL

As showed, the firewood-burning appliances for residential heating (stoves, fireplaces etc.) play the major role, accounting for the 62% of the market. Pellet-burning appliances for residential heating accounts for the 11%, while boilers at residential level (both firewood and pellet-burning) for the 15% if summed. An important role in terms of consumption is played also by DHS, accounting for a 12% considering both large (>1MW) and mini (<1MW).

AIEL concludes from this new study that it is nowadays evident, thanks to this and several other studies conducted in the last years (*i.e.* Antonini e Francescato, 2011; Pettenella and Andrighetto, 2011, APAT, 2003) that the woody biomass for energy market in Italy has very important dimensions, with over 10 million of installed appliances and over 27 million tons of woody biomass consumed yearly according to the present estimation. This growing trend in consumption is considered to be driven by:

- A positive trend of the market of biomass-burning heating appliances;

- An important advantage in terms of cost of energy compared to fossil fuels, which is more and more an important factors considering the economic crisis currently affecting the country and the raising prices of gas and other fossil fuels;
- The supporting policies and current incentives-schemes, which are giving a significant boost to the market.

Finally, if translating this data in energy consumption terms, it result in 9 Mtoe, which would mean that the NREAP target for solid biomass (5.2 Mtoe, including thus other biomass sources) has been already reached just by woody biomass.

Surely, due to some assumption and limitations this study does not aim at provide a precise estimation, but the overall data presented raise an urgent need to revise the programmatic assumption of the Italian renewable energy strategy and investigate more in understanding how the supply chain is structured and how to assess the sustainability of the sector.

4.2 Experts' assessment of the informative sources and data consistency

Given the discrepancies and the uncertainty of the informative framework on the woody biomass for energy market in Italy as showed in the previous section, the main informative sources have been assessed through a consistency analysis based on experts' opinion.

The consistency of the informative sources has been assessed by panel of experts, on the bases of the overall informative framework presented and their individual knowledge, through a consistency scale:

- "Very reliable",
- "Sufficiently reliable",
- "Poorly reliable",
- "Not reliable",
- "I do not know".

The data have been result of the consistency assessment carried out is in this section presented and discussed for the four identified sections:

- Data on internal production,
- Data on import,
- Data on indirect supply from industry and post-consumption used wood,

- Data on consumption for energy production,

The spreadsheets with all the responses from the Delphi survey questionnaire can be found in Annex 3.

Internal production. Concerning the internal production, the informative sources under focus have been ISTAT, FAOSTAT and Eurostat (see Table 6 and Table 9). The results of the expert's consistency analysis for the production data are presented in Table 19, where in the columns are showed the informative sources under focus and on the rows the consistency scale. The numbers shows are referred to the number of experts (*i.e.* five experts considers "poorly reliable" the ISTAT data on production).

Table 19: Production data consistency according to the panel of experts

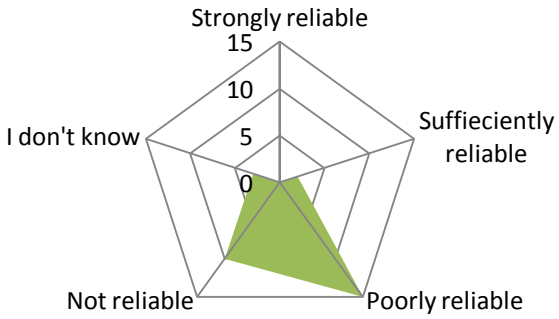
	ISTAT	FAOSTAT	Eurostat
Strongly reliable	0	0	0
Sufficiently reliable	1	0	1
Poorly reliable	5	5	5
Not reliable	4	4	2
I do not know	0	1	2

For what concerns the single sources, the data on fuelwood removals presented by ISTAT (2011) of 5.08 million m³ are considered "not reliable" (4 experts) or "poorly reliable" (5) by the majority of the experts, while just one considered it as "sufficiently reliable". The almost same opinion has been given by the experts to FAOSTAT data, that were along the lines of ISTAT's one for what concern fuelwood removals, but which showed new data concerning woodfuels production (1.09 million m³ of chips and 300 thousand tons of pellets). The data of Eurostat, which were related only to pellets production (816 thousand tons), has been considered mostly as "poorly reliable" by the expert (5).

If, beside the single sources, we look at the overall informative framework on production of woody biomass for energy in Italy (summing together all the single sources), as showed graphically in Figure 15, we clearly see that the general consideration emerged from the experts' panel is of a poor (15) or not reliability (10) of the data.

Furthermore, in the comments it has been highlighted that "*the data, especially the ones regarding fuelwood removals from forest, are inconsistent mainly because of the fragmentation of the regional statistics built with different methodologies and without a national level coordination*" (Hellrigl).

Figure 15: Production data consistency according to the panel of experts



Import. In the assessment of the import data, we included as informative sources the main international and regional trade database such as FAOSTAT, Eurostat and UNCOMTRADE (See Table 10). The results of the consistency analysis are showed in *Table 20.*

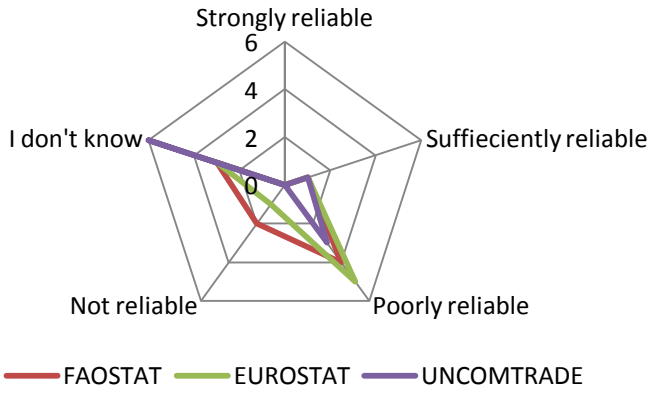
Table 20: Import data consistency according to the panel of experts

	FAOSTAT	Eurostat	UNCOMTRADE
Strongly reliable	0	0	0
Suffieciently reliable	1	1	1
Poorly reliable	4	5	3
Not reliable	2	1	0
I do not know	3	3	6

The FAOSTAT data showing a total woody biomass import (including firewood, chips, pellets, and waste and residues) of about 2.43 million tons were evaluated mainly as “poorly reliable” by four experts, “not reliable” by two, while three people did not express any opinion, due to their lack of experience concerning trade flows. A nearly analogous assessment has been given to Eurostat data, which regarded only 500 thousand tons of firewood import and 1.2 million tons of pellets. UNCOMTRADE showed a value of 3.06 million tons of woody biomass import, but most of the expert (6) did not give an evaluation to this source.

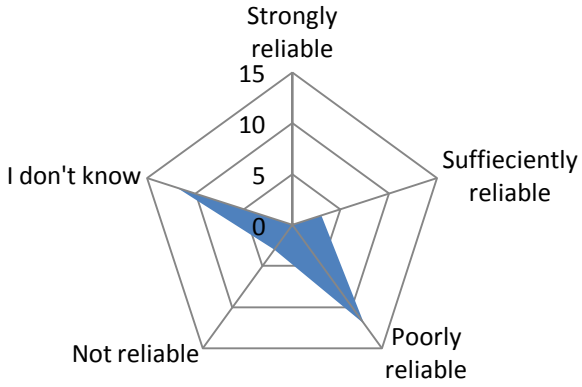
A comparison between the assessments of the three informative sources as emerged from the experts’ panel consultation is showed in a radar graph in Figure 16, where it can be observed that generally the level of knowledge on the import flow is much lower than for the production data. Indeed, three experts did not express any evaluation for FAOSTAT and Eurostat data and even six for UNCOMTRADE data.

Figure 16: Consistency analysis of import data by informative source



However, if as we did with the production data, we look at the entire informative framework (in Figure 17), we can see that from the expert's opinion emerge a general idea of poor consistency of the import data. In any case, the strong assessment of non reliability of the sources emerged less (3) compared to the production data, meaning that despite a general uncertainty, the informative bases of thee three sources related to import are considered slightly more coherent.

Figure 17: Import data consistency according to the panel of experts



Looking at the comments that arise from this section, one expert stated that "*the import data are often second (or third) elaboration, thus poorly reliable not because of the source itself, but because of the mechanism through which they are generated*" (Hellrigl).

Moreover, it has been reported that "*all these data derived from the same official sources based on customs declarations. However, in the case of Italy is clear that there is an underestimation in the import data considering the high levels of consumption estimated, which absolutely impossible can't derive all from internal production*" (Expert 1).

Finally, one expert also noted that "*the origin of these data are more or less the same (with an exception for UNCOMTRADE which probably uses different definitions) and except for firewood import, are realistic*" (Gottero).

Indirect supply from industry and post-consumption wood. Concerning the indirect supply from the industry we took into consideration the studies of ITABIA (2008), ENAMA (2011) and Rilegno (See Table 12). The results of the analysis are showed in Table 21.

Table 21: Indirect supply data consistency according to the panel of experts

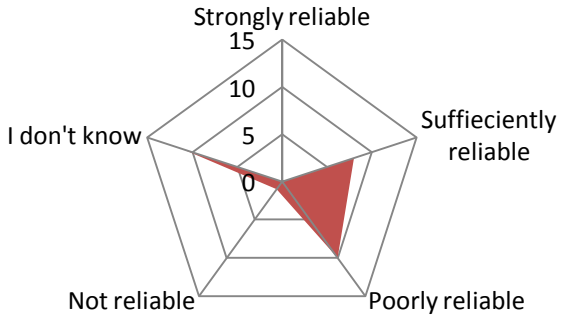
	ITABIA (2008)	ENAMA (2011)	Rilegno (2013)
Strongly reliable	0	0	0
Suffieciently reliable	1	5	2
Poorly reliable	6	2	2
Not reliable	0	0	1
I do not know	3	3	5

The complexity of the matter is here reflected in the number of experts that decided to do not express any evaluation in front of the data provided. However, among the experts, there is a general opinion of sufficient reliability (5) for the figures provided by the ENAMA's study of 1.80 million tons of woody biomass available from the wood-processing industry and 150 thousand tons from the pulp and paper industry. It has been highlighted as more difficult to evaluate the data on post-consumption used wood, where in the case of the Rilegno figure, half of the expert panel did not express any opinion.

Anyhow, this section has been largely commented by the panelists. The general idea that comes to light is that it is arduous to express an opinion in quantitative terms, due to the complexity of the logistics of the chain. According to Hellrigl "*one of the main complexities is that the amount of residues and wastes produced strongly depends on the production process, on which is difficult to gather general information, indeed all the presented estimates are poorly realistic because are not built from any informative based*". Also another expert (anonymous) noted that "*is very hard to express an opinion on these estimations, mainly because the methodologies behind are not clear*".

The results for the overall informative framework on indirect supply from industry are showed in Figure 18, where the assessments "Poorly reliable" and "I do not know" emerged as the most frequent ones.

Figure 18: indirect supply data consistency according to the panel of experts



Other experts gave some extra input to the discussion. Tomassetti commented that "*there are other industrial sectors which potentially consume large quantities of wood. For instance in the construction sector the small and medium enterprises use timber formworks made of 2-2.5 mm beams, which after their use are usable only for fire, and this mainly happens in the construction sites or in workers' houses*". Finally, Gottero underlined that "*in any case, the recent economic crisis sensible influenced the wood processing industry, thus the current situation is difficult to be comparable with the 2008 one (referring to the ITABIA estimate) in terms of residues and waster availability*".

Consumption for energy purposes. For the consumption levels of woody biomass for energy purposes we took into consideration a larger amount of sources. The informative framework presented to the panelists included official and non-official data (See Table 13 and Chapter 4.1.4). In specific:

- The data on firewood usage ("*legna da ardere e faciame*") provided by ISTAT in 2010;
- The data from the National Energy Balance (BEN, 2012) referring to the total household consumption and total overall consumption;
- GSE (2009) data for what concern the consumption of biomass-based power plants (and CHP);
- Data from AEBIOM concerning specifically the pellet consumption (AEBIOM, 2008);
- The data from the estimation of Antonini and Francescato (2010) regarding al all woody biomass consumption divided by subcategories;
- The estimation from ARPA (2003) on the total consumption in Italy;
- Finally, with regards to household consumption we included some of the surveys carried out in the last years:
    - *Istituto di Sociologia Rurale* (ISR) of 1998;

- APAT of 2003;
- ARPA of 2006;
- Marazzi *et al.*, 2006.

Special attention has been paid then to assess the experts' opinion on, firstly, the new estimation of the consumption levels of woody biomass based on the installed capacity made by AIEL and, secondly, on the result of our tentative estimation of the households fuelwood consumption based on the information on the expenditure gather from the analysis of the ISTAT "Survey on consumption by families" results. This last is presented in the next chapter, together with the results of the surveys' analysis (See Chapter 5.2).

The results for the consumption level informative sources, as in the other section, are presented in Table 22.

Table 22: Consumption data consistency according to the panel of experts

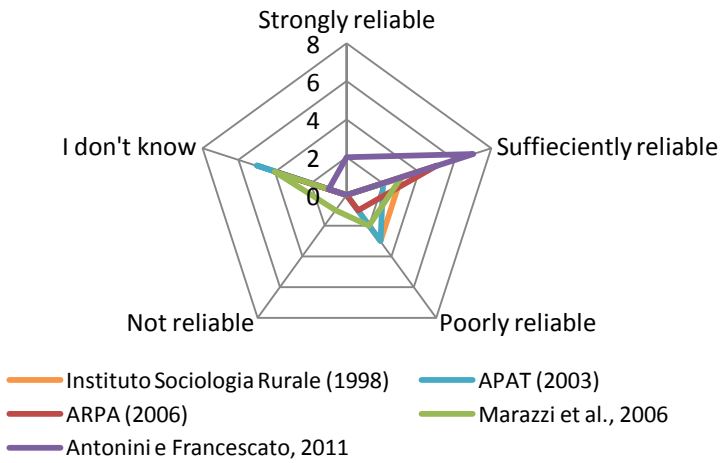
	Istat	ISR (1998)	APAT (2003)	ARPA (2006)	Marazzi et al, 2006	AEBIOM (2008)	GSE (2009)	Antonini eFrancesca to, 2011	BEN (2012)
Strongly reliable	1	0	0	0	0	0	2	2	0
Suffiecienty reliable	0	3	2	5	3	3	3	7	1
Poorly reliable	2	3	3	1	2	2	1	0	3
Not reliable	7	0	0	0	1	1	0	0	1
I do not know	0	4	5	4	4	4	4	1	5

Looking at the single informative sources, there are some evident elements that come to light. It has been noted by large part of the experts (7) the inconsistency of the last official data provided by ISTAT (2010) of a usage level of about 3.78 million tons of firewood usage The GSE data of 1.80 Mt of chips consumption in biomass-based power plants are generally considered as sufficiently (3) and strongly reliable (2), although also 4 experts did not express any opinion. For what concerns then the household consumptions' estimations presented, there is a general unawareness, showed by the number of expert not providing an evaluation in the results. However, the ARPA (2006) and Antonini and Francescato (2010) estimations are considered as the most consistent by the experts based on their knowledge. ARPA estimate of 19 million tons of household consumption is considered to be "sufficiently reliable" by five experts, while the estimate provided by Antonini and Francescato of 23.60 million tons of total consumption, of

which 21 million tons at household level, is considered to be “very reliable” by two experts and “sufficiently reliable” by seven.

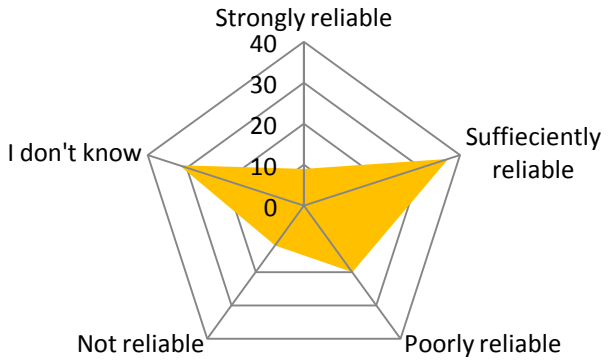
The results for what concern the five estimations data are showed graphically in the radar chart in Figure 19.

Figure 19: Households consumption studies consistency



Even though the informative framework for what concerns woody biomass consumption is made of very different informative sources and data, it is interesting also here to see to summed results, as in Figure 20.

Figure 20: Consumption data consistency according to the panel of experts



It can be observed the overall result is very heterogeneous, especially among “sufficiently reliable”, “poorly reliable” and “I do not know”. However it emerges that the level of consistency is considered to be higher than for the other section, but this not as a result of the overall informative framework, but of some informative sources (Antonini and Francescato,

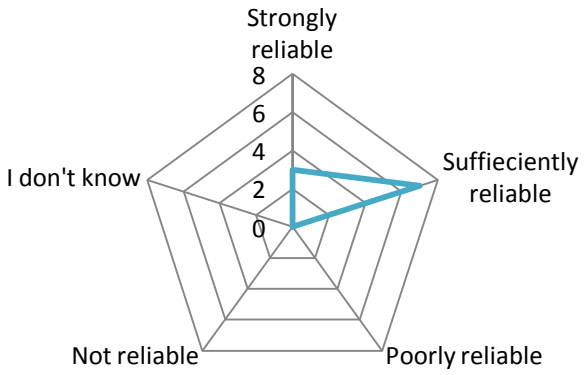
2010; ARPA, 2006; GSE, 2009) which have got a significant higher level of reliability by the experts.

Among the comments, Mori highlights that "*from the data on forest surfaces under cutting authorization in the Tuscany region we can estimate a 1.1 million tons of fuelwood removals for the region. Then, another study in Piedmont (referring to the IPLA study) in 2006 reports a household consumption of fuelwood of 2.89 million m³ for the only Piedmont region, which corresponds according to the coefficient used to around 1.44 million tons. Although these two estimates are conducted in different years and with different methodologies, the sum is of around 2.5 million tons just for these two regions, thus the official data are clearly underestimated and the household consumption is likely to be much higher*".

Consistency of the new AIEL's woody biomass consumptions estimation. As mentioned before, in the consistency analysis particular importance has been given to assess the experts' opinion towards the new AIEL estimation of the woody biomass consumption levels in Italy (see *Chapter 4.1.6*).

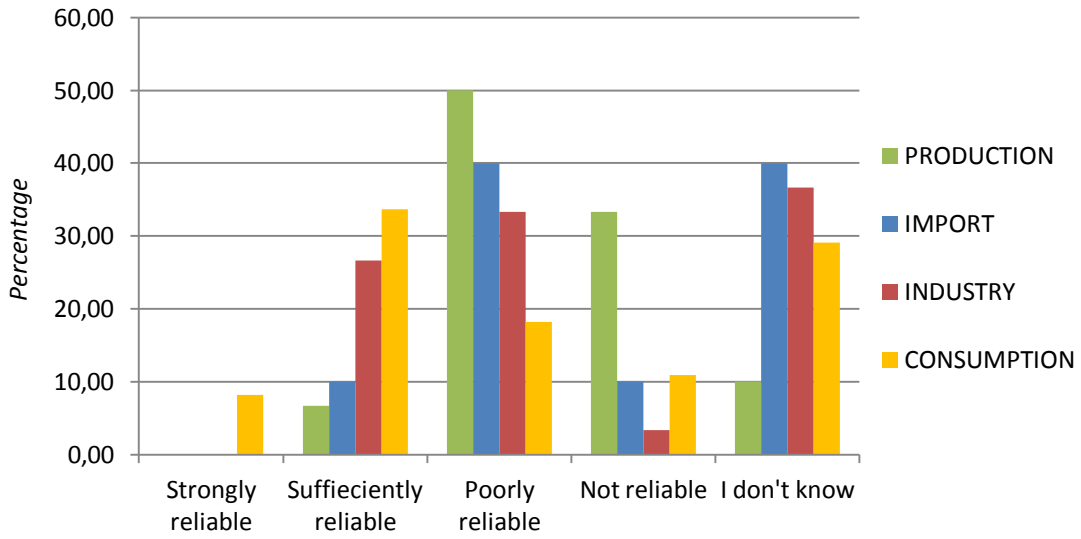
The results, presented in *Figure 21*, are very positive in terms of consistency level expressed by the expert. So, the estimation made by AIEL based on the installed capacity of 27.30 million tons of woody biomass consumption in Italy, of which 22.25 Mt in the residential sector is considered to be "sufficiently reliable" by seven experts and even "strongly reliable" by three.

Figure 21: Consistency of AIEL's estimation according to the panel of experts



Overview of the results of the consistency analysis and discussion: An overview of the responses, presented in percentage, concerning the consistency of the informative frameworks for four market sections is showed in Figure 22.

Figure 22: Overview of the results of the consistency assessment



According to the consistency assessment made by the panel of expert involved in the analysis, there are some overall considerations that can be drawn:

- The data on internal production of woody biomass for energy results to be less consistent according to the evaluation of the experts. Almost all the panellists expressed an opinion about it (in fact only the 10% responded “I do not know”), half (50%) considers the data on production as poorly reliable and the 33% as not reliable. Thus, the internal production informative framework results as the most critical section in terms of consistency and information available.
- There is in the analysis a high level of uncertainty and lack of knowledge concerning quantitative data on the market. Indeed, 40% of the experts’ responding on the import data, 37% of the ones concerning the indirect supply from industry and 29% of the ones on consumption did not provide an assessment of the quantitative data (“I do not know”). Moreover, there is a considerable heterogeneity in all the section, as a demonstration of the low level of information on the market.
- The data on consumption, despite an overall heterogeneity, are the ones were the consistency level appears to be higher, with 33% of sufficiently reliable and

8% of very reliable (only section with this result). In particular a very high level has got by the market estimation of Antonini and Francescato (2010) of 23.60 million tons of woody biomass and AIEL's one of 27.80 million tons (AIEL, 2014). This might demonstrate that among the experts there is a more clear idea of which are the consumption levels of woody biomass in Italy, and are thus the ones showed by those two studies.

5. Fuelwood consumption at household level based on the ISTAT "Survey on consumption by families"

This chapter presents the results of the analysis of the "Survey on consumption by families" organized by ISTAT, focusing on use and expenditure for fuelwood by Italian households. On the bases of the survey, information on the number of households using fuelwood, on the level of expenditure, and other interesting insights are provided (5.1). Moreover, an estimation of the consumption levels for fuelwood on the basis of the expenditure is presented (5.2), reporting also its consistency assessment by the panel of experts and a discussion of the results comparing them to other surveys' outcomes.

5.1 Results of the analysis of the ISTAT "Survey on consumption by families"

The "Survey on consumption by families" is carried out by the Italian National Institute of Statistics (ISTAT) since 1997, and the results are currently available up to 2012. It provides information on the expenditure for goods and services of household resident in Italy, including the variable "fuelwood and charcoal" ("*legna da ardere e carbone*"), which for the focus of our analysis. The survey involves a large number of families (from 23,000 to 31,000 depending on the year), which are committed to compile a weekly record of expenses.

In this section the results and elaborations that have been made from the analysis of the data of the ISTAT's survey are presented. We have considered in detail the following topics:

- Household using fuelwood in Italy (number and percentage),
- Annual expenditure for fuelwood in the residential sector in Italy,
- A comparison between fuelwood and other fuels and energy sources at household level.

5.1.1 Households using fuelwood in Italy

Table 23 presents the results of the households using fuelwood in Italy, meant as the number of household that according to the survey are registering an expenditure for fuelwood in their weekly records. In the second column the total number of households is reported; in the

third one the number households consuming fuelwood in their primary residence, and in the fourth the number of households consuming fuelwood in their second houses. The fifth and sixth columns show the total number of household registering expenditure for fuelwood and their percentage over the total number of Italian households.

Table 23: Use of fuelwood among households in primary residence and second house

Year	Total Italian household	Households with expenditures for fuelwood (primary res.)	Households with expenditures for fuelwood (2nd house)	Total households with expenditure for fuelwood	%
1997	21,458,828	1,271,849	55,308	1,327,158	5.93
1998	21,643,985	1,132,437	54,469	1,186,905	5.23
1999	21,770,664	1,313,082	52,150	1,365,232	6.03
2000	21,967,028	1,222,356	52,150	1,274,506	5.56
2001	22,191,989	1,220,505	39,146	1,259,651	5.50
2002	22,270,166	1,023,324	42,938	1,066,262	4.60
2003	22,270,165	996,083	44,055	1,040,138	4.47
2004	22,813,192	1,035,109	37,002	1,072,111	4.54
2005	23,267,710	1,058,527	32,328	1,090,854	4.55
2006	23,567,059	1,112,537	27,622	1,140,160	4.72
2007	23,881,224	1,122,620	34,938	1,157,558	4.70
2008	24,257,661	1,260,908	29,455	1,290,363	5.20
2009	24,609,430	1,166,273	18,655	1,184,928	4.74
2010	24,898,006	1,456,776	55,646	1,512,422	5.85
2011	25,165,002	1,403,387	41,495	1,444,882	5.58
2012	25,383,757	1,486,923	55,954	1,542,877	5.86

Data: ISTAT

Taking the last year (2012) as reference, the results shows that out of 25,383,757 households in Italy, 1,486,923 are registering expenditure for fuelwood and charcoal, thus the 5.86% of the total. More in detail, out of this nearly one and half million households using fuelwood, the large part (96.40%) in primary residences, while only the 3.60% in the second houses.

For the use of fuelwood in second houses, more specific data are presented in Table 24. The number of second house holders is showed in the second column. The percentages of fuelwood users in second houses has been calculated both over the total number of households (third column) and only over the second house holders (column four).

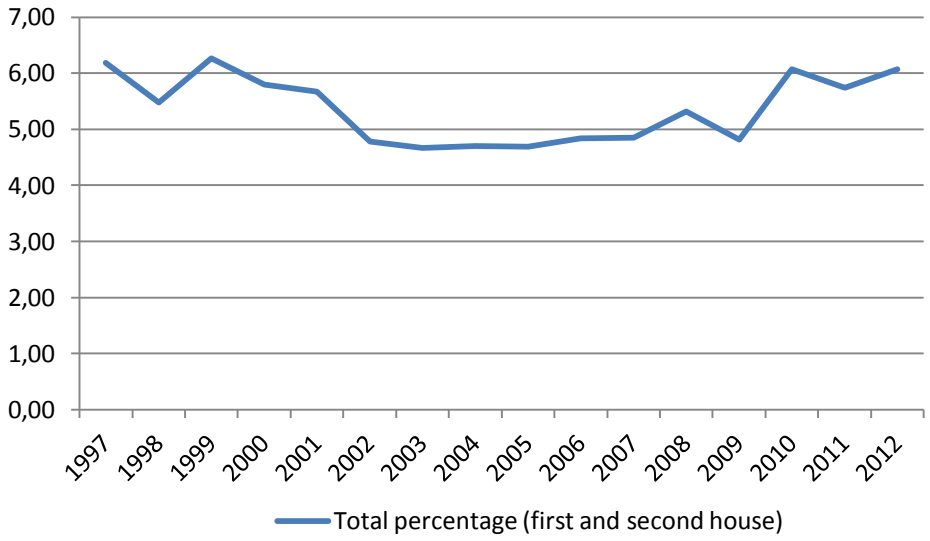
Table 24: Fuelwood use in second houses

Year	2nd house holders	Households with expenditures for fuelwood (2nd house)	% on total households	% in the 2nd house holders
1997	1,834,955	55,308	0.26	3.01
1998	2,028,704	54,469	0.25	2.68
1999	1,933,701	52,150	0.24	2.70
2000	1,933,701	52,150	0.24	2.70
2001	1,824,279	39,146	0.18	2.15
2002	1,736,630	42,938	0.19	2.47
2003	2,139,885	44,055	0.20	2.06
2004	2,021,207	37,002	0.16	1.83
2005	1,866,064	32,328	0.14	1.73
2006	3,339,359	27,622	0.12	0.83
2007	1,874,226	34,938	0.15	1.86
2008	2,010,998	29,455	0.12	1.46
2009	2,292,876	18,655	0.08	0.81
2010	2,393,472	55,646	0.22	2.32
2011	2,314,332	41,495	0.16	1.79
2012	2,438,987	55,954	0.22	2.29

Data: ISTAT

Considering again 2012 as reference year, it results that the 2.29% of the 2,438,987 second house holders consumes fuelwood in their second houses, the 0.22 of the entire households population. Beside the specific annual data, it is very interesting to look at the trend of households using fuelwood. Figure 23 shows the total percentage of households registering an expenditure for fuelwood along the 1997-2012 period. Analysing the figure, a general trend can be identified: until the beginning of the last decade (2002-2003) there was a decrease in the use of fuelwood among households in Italy. Unfortunately data series longer in time are not available, but we can assume that this decrease is just the final part of a longer trend of replacement of fuelwood with other types of fuels and energy at household level, such as gas, which has become more and more available in Italy since the 60s and 70s. Secondly, it can be observed that, from the beginning of the 2000s there is a clear change in the trend, which starts slowly to increase again, especially in the last two-three years (i.e. starting from 2010). The slight drop in 2009 is probably the result of the economic crisis which affected significantly households' consumption in general. However, we can observe that since one decade, the number of household that are using fuelwood in their primary residence is growing.

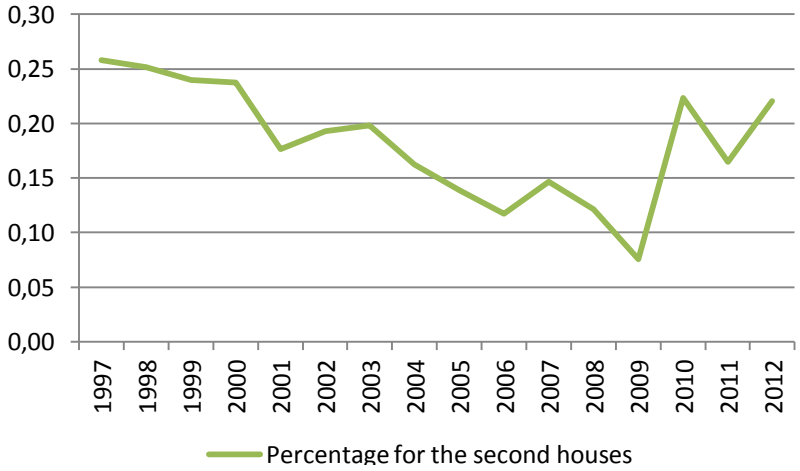
Figure 23: Percentage of household consuming fuelwood 1997-2012



Data: ISTAT

As said, the households consuming fuelwood in their second houses is minimal if compared to the total. However it is interesting to see the trend for what concern the number of households registering this expenditure in second houses, again along the whole data series. This is showed in Figure 24.

Figure 24: Number of households consuming fuelwood in second house 1997-2012



Data: ISTAT

The trend showed in the figure is slightly different from the one concerning the primary houses. A significant increase in the last years can be observed in the figure, although we are talking about a low significant number if compared to the primary residence's numbers.

However, interpretation of the data on second houses is much more complex as the second houses market has been subjected to important changes in these last years due the economic crisis.

An interesting insight is provided analyzing the results of the survey among the different Italian regions; this has been done only for the year 2012 and the results in absolute and relative values are reported in Table 25.

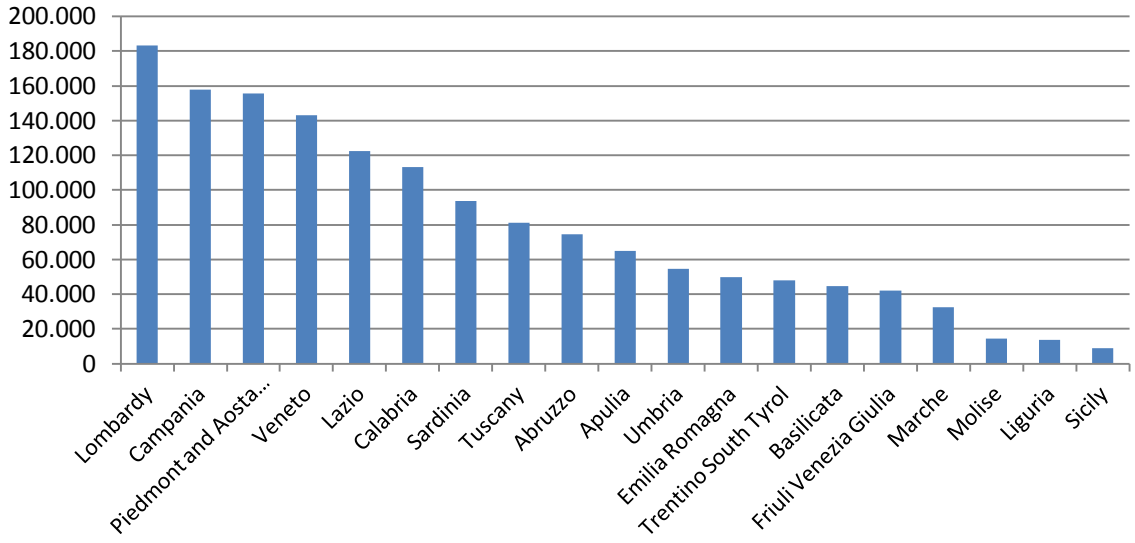
Table 25: Households using fuelwood among Italian regions

Region	Tot. No. of households	No. of households using fuelwood	% of household using fuelwood
Piedmont and Aosta Valley	2,055,155	155,588	7,57
Lombardy	4,255,993	183,295	4,31
Veneto	2,006,906	142,978	7,12
Lazio	2,319,586	122,380	5,28
Calabria	771,076	113,206	14,68
Campania	2,087,155	157,878	7,56
Abruzzo	537,463	74,466	13,86
Sardinia	679,928	93,762	13,79
Tuscany	1,601,371	81,039	5,06
Umbria	373,804	54,689	14,63
Basilicata	227,968	44,538	19,54
Friuli Venezia Giulia	554,987	42,156	7,60
Apulia	1,527,221	64,852	4,25
Trentino and South Tyrol	426,343	48,167	11,30
Emilia Romagna	1,942,252	49,731	2,56
Marche	637,545	32,508	5,10
Molise	128,234	14,399	11,23
Liguria	785,105	13,855	1,76
Sicily	1,979,912	9,024	0,46
Total Italy	24,898,006	1,498,507	

Data: ISTAT

The regions with the highest number of households using firewood are the northern regions of Lombardy, Piedmont (calculated together with Aosta Valley) and Veneto, and the southern and central regions of Campania, Lazio and Campania. The regions with the lowest number of households using fuelwood are Sicily, Liguria and Molise (see Figure 25).

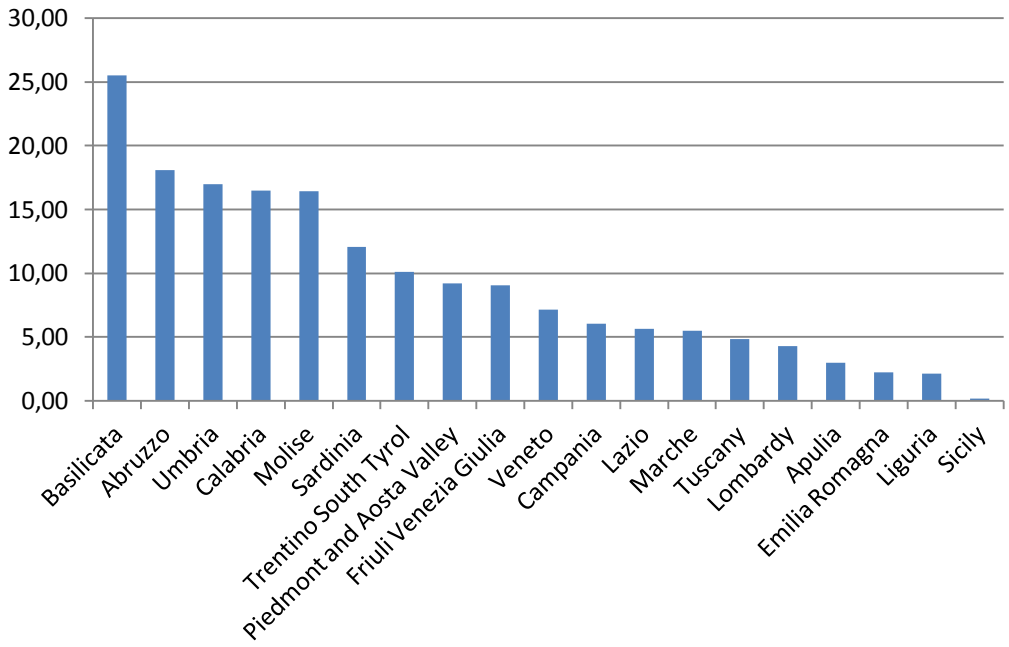
Figure 25: Fuelwood use in the Italian regions



Data: ISTAT

Due to the largely different population levels of the regions, the percentage of households using firewood out of the total varies quite significantly. Figure 26 gives an overall idea of how common is the use of fuelwood among the regions.

Figure 26: Percentage of household using fuelwood in the Italian regions



Data: ISTAT

As it can be observed, inspite what the absolute values shows, the use of fuelwood results in higher in southern and central regions, in particular in Basilicata, Abruzzo, Umbria, Calabria and Molise. Apulia, Emilia Romagna, Liguria and Sicily are the regions where the use of fuelwood is less spread on the population, in particular in Sicily, due probably also to favorable climatic conditions, the use of fuelwood is very limited.

5.1.2 Total yearly expenditure for fuelwood in the household sector

In Table 26 are showed the data concerning the annual expenditure level for fuelwood at household level in Italy. In the first column the data regarding the primary residence, in the second column for the second house, and the total in the third column.

Table 26: Total expenditure for fuelwood at household level

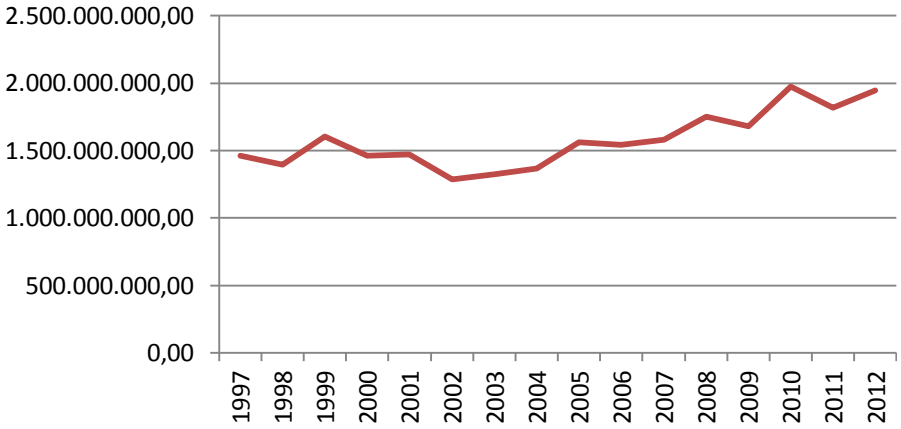
Year	Total expenditure for fuelwood (primary residence)	Total expenditure for fuelwood (2nd house)	Total expenditure for fuelwood
1997	1,434,612,215.02	24,535,023.37	1,459,147,238.39
1998	1,368,738,293.28	24,576,176.94	1,393,314,470.22
1999	1,576,263,486.36	26,716,677.57	1,602,980,163.93
2000	1,436,762,717.05	26,060,687.72	1,462,823,404.77
2001	1,450,241,521.72	22,487,602.04	1,472,729,123.76
2002	1,267,954,981.15	19,140,891.27	1,287,095,872.41
2003	1,307,581,765.96	16,954,379.01	1,324,536,144.97
2004	1,340,477,188.33	24,337,837.74	1,364,815,026.07
2005	1,545,373,365.60	16,698,840.91	1,562,072,206.51
2006	1,520,625,648.94	21,815,520.07	1,542,441,169.02
2007	1,555,173,558.39	23,057,665.15	1,578,231,223.54
2008	1,724,940,428.63	24,322,724.53	1,749,263,153.16
2009	1,671,029,369.21	10,043,380.61	1,681,072,749.82
2010	1,942,961,795.27	30,752,351.94	1,973,714,147.21
2011	1,796,240,907.29	20,593,711.83	1,816,834,619.12
2012	1,921,340,814.33	23,750,256.03	1,945,091,070.36

Data: ISTAT

As showed, the expenditure for fuelwood in the household sector was nearly 2 billion Euros (1,945,091,070 Euros) in 2012. The majority of which coming from primary residences (98.78%), and the rest in second houses (1.22 %).

In Figure 27 is showed the trend in real values of the expenditure for fuelwood at household level.

Figure 27: Expenditure for fuelwood by Italian households 1997-2012

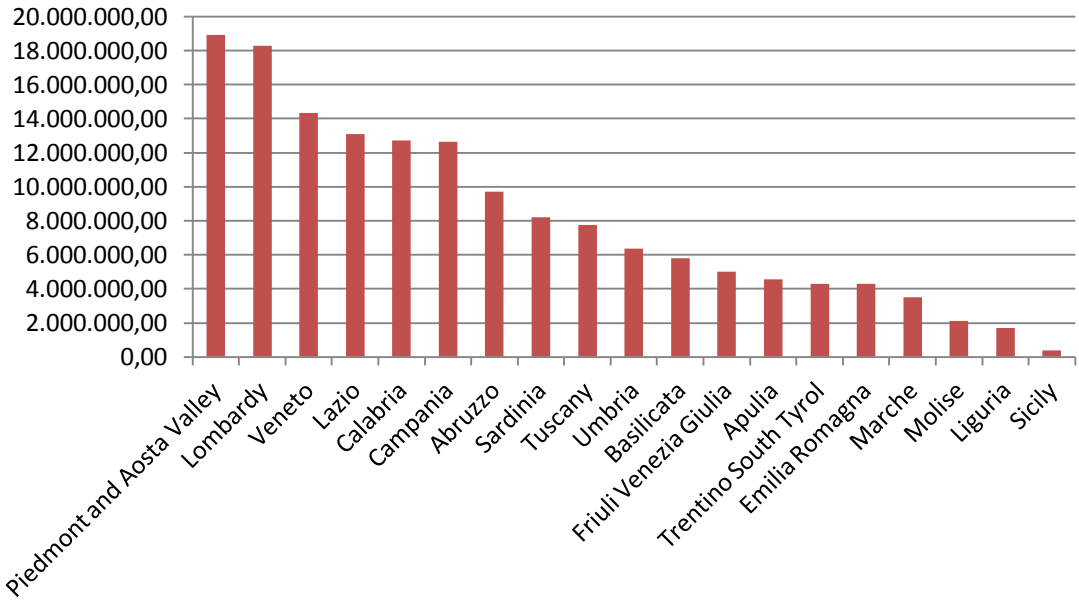


Data: ISTAT

It can be observed from this figure that there is a clear trend of increase since the beginning of the previous decade (2002-2003) and linear until the most recent year of the data series. It has also to be taken into consideration the overall increase of woodfuels prices over the last decades (see Table 4).

Also here the data have been analyzed region by region for the year 2012. The results are showed in Figure 28.

Figure 28: Consumption by region



Data: ISTAT

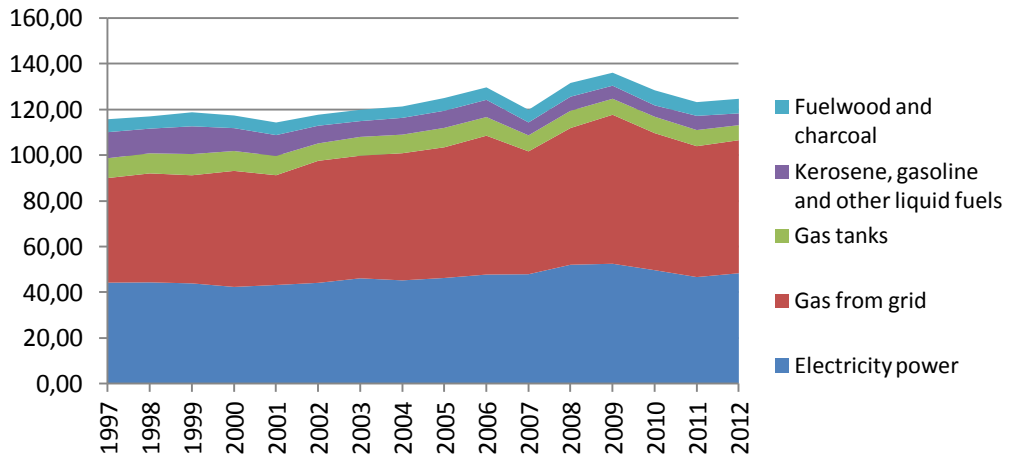
As showed, the regions with the largest fuelwood market at household level are Piedmont (with Aosta Valley) and Lombardy, with expenditure levels over 18 million Euros yearly. Other important regions are Veneto, Lazio, Calabria and Campania, with an expenditure higher that 12 million Euros. On the other side of the figure, Molise, Liguria and Sicily are the regions with the lower market for fuelwood, less than 2 million Euros yearly, reflecting basically the number of people consuming fuelwood.

5.1.3 Fuelwood versus other energy fuels at household level

The last interesting analysis carried out on the ISTAT survey regards with the comparison between fuelwood and other energy fuels or energy expenditure at household level. The result has been analyzed for the primary residence and second house together.

Figure 29 shows the monthly average expenditure level for energy divided for electricity power, gas from grid, gas in tanks, kerosene, gasoline and other liquid fuels and fuelwood.

Figure 29: Average expenditure for different fuels/energy at household level

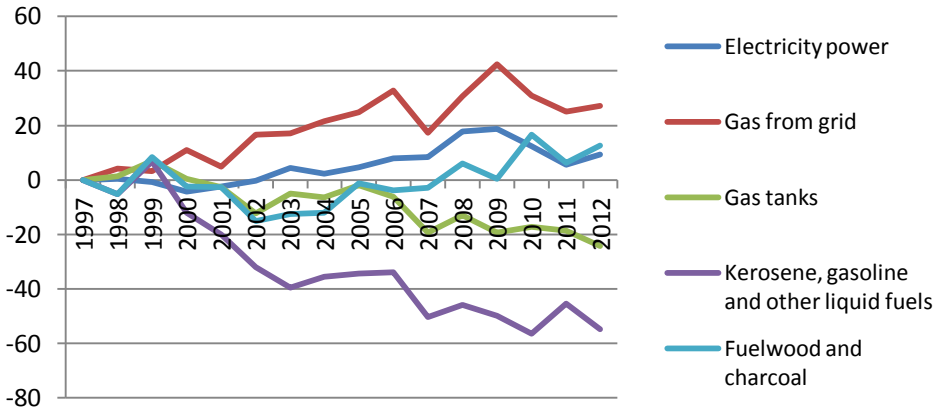


Data: ISTAT

As it can be observed, on average the large portion of expense is for electricity power and gas from grid at household level, while other energy fuels as gas in tanks, kerosene, gasoline and other liquid fuels and finally fuelwood accounts for a minor.

More than the absolute values are interesting to see the percentage variation along the data series for the different fuels and energies. This is showed in Figure 30.

Figure 30: Percentage variation for different fuel/energy at household level



Data: ISTAT

As seen, since the beginning of the data series, electricity, gas from grid and fuelwood are showing an increase, while gas in tanks and kerosene and liquid fuels are decisively decreasing in terms of use.

5.2 An estimation of the fuelwood consumption at household level

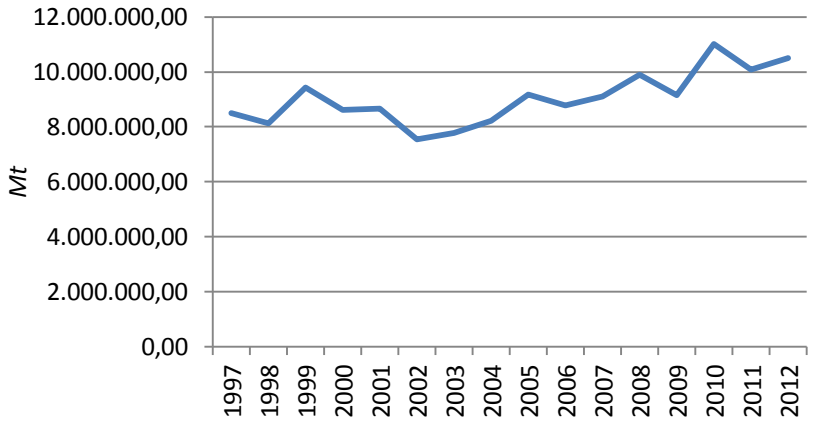
For the estimation of the fuelwood consumption at household level, we used the data on the expenditure gathered from the survey analysis and calculate the quantity using a Consumer Price Index (CPI) of firewood. In the survey our focus variable was “fuelwood and charcoal” (“*legna da ardere e carbone*”), however, in order to facilitate the calculation we did not considered charcoal because it results from the Italian National Energy Balance (BEN) to play a minimal role in households terms, the 0.03% (BEN, 2012). The results of the calculation are showed in Table 27.

Table 27: Estimation of fuelwood consumption at household level 1997-2012

Year	Total fuelwood consumption
1997	8,497,425,30
1998	8,114,044,51
1999	9,431,447,58
2000	8,606,807,85
2001	8,665,090,08
2002	7,553,379,53
2003	7,773,099,44
2004	8,219,301,57
2005	9,175,167,15
2006	8,788,838,57
2007	9,109,559,73
2008	9,899,621,69
2009	9,156,169,66
2010	11,010,957,59
2011	10,076,731,11
2012	10,491,321,85

From our calculation, the consumption of fuelwood in 2012 was nearly ten and half million tons (10,491,321.85 tons). The historical trend, which is alike the one for expenditure (Figure 27) is shown is Figure 31.

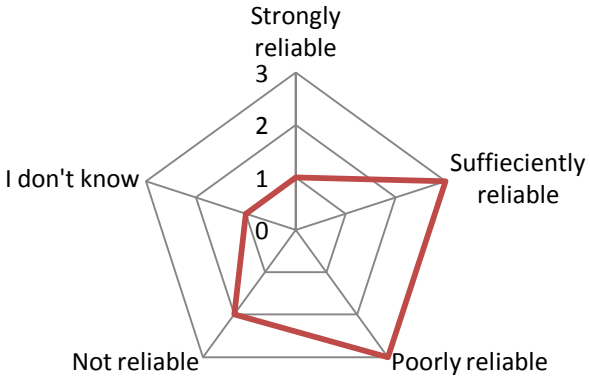
Figure 31: Fuelwood consumption at household level trend



Consistency assessment by the experts' panel and final considerations: as mentioned previously, special attention has been given in presenting this estimation to the panel of expert in the context of the consistency analysis (see Chapter 4.2).

The results of the reliability assessment are showed in Figure 32. As it can be observed, the opinions of the respondents toward the estimation resulting from the ISTAT survey analysis are very diverse. Three experts considered the estimation “sufficiently reliable”, other three as “poorly reliable”, and two as not reliable at all. Just one considered it as “strongly reliable”, mainly because of the source from which the survey was carried out, another one did not express any opinion.

Figure 32: Consistency analysis of our estimation based on ISTAT survey



Focusing on the comments that emerged, Hellrigl considered it a good estimation because “*generally the data obtained from the consumer standpoint are likely to be less biased than the ones from the seller side*”. On the other hand, Tommassetti considers that “*the estimate is not very reliable mainly because of the scale of the survey (that had fuelwood just as one among hundreds variables), it is very difficult to homogenize and coordinate such large survey, especially with information on expenditure level which is a delicate topic*”.

Interesting is also to compare the results obtained from the analysis and from the calculation with the results from some of the survey conducted in the last years and presented in the previous section (Chapter 4.1.3). With regards to the different results obtained from the analysis of the survey in terms of number of households using fuelwood and expenditure level, we can draw the following considerations:

- Concerning the number/percentage of households using fuelwood, three survey carried out in the last years provide this information. The ENEA’s survey in 1999 showed that this was 22% (biomass); FLA Lombardy considering just the regional population, showed that the percentage of households using fuelwood was 25%. ARPA (2006) found that 20% of the households were using woodfuels at least four times per year. From the analysis of this ISTAT’s survey the number of households using fuelwood is considerably lower than what these mentioned surveys showed. A comparison is presented in Figure

33, showing the result from the ISTAT's survey analysis for the reference years of the various surveys. As showed there is a considerable discrepancy. However, both ENEA and FLA surveys reported that respectively the 47 and 50% of the households consumed fuelwood from self-production. This element can partially explain the discrepancy, as we assume that in the ISTAT survey, where the household are required to compile a monthly expenses registers, the self-consumption does not emerge.

Figure 33: Comparison of fuelwood users estimations

	Reference year	% of households using fuelwood	ISTAT survey (in the same year)
ENEA	1999	22%	6.03%
FLA Lombardy	2004	25%	4.54%
ARPA	2006	20%	4.72%

- This expenditure level resulting from the ISTAT survey of 1,945,091,070 Euros does match to the value suggested by Ciccarese *et al.* (2012), reporting that from the estimation of an internal consumption of logwood (firewood) as energy source of 19 million tons (APAT/ARPA, 2006), the economic equivalent results in of nearly 2 billion Euros.

Concerning then the tentative estimation of the consumption on the bases of the expenditure level resulting from the survey analysis, we can observe:

- If we compare them the result of our calculation with some of the results of the estimations made by other studies some differences emerges. For instance, the ENEA survey in 1999 estimated a total consumption of 14.60 million tons of biomass at household level, 19 Mt (woodfuels) by ARPA (2006), 22.60 Mt by Marazzi *et al.*, (2006) (firewood), and finally 22.25 Mt from the presented recent AIEL study (woodfuels). Even though the value obtained of 10.50 million tons of fuelwood is to be considered as very high given the type of survey from which the information has been calculated, this is evidently low if compared to the other estimations. See Figure 34.

Figure 34: Comparison of household fuelwood consumption estimations

Source	target	Methodology used	Year	Estimation
ENEA	Biomass in general	Phone interviews to a representative sample of 6000 households	1999	14.60 Mt
APAT-ARPA	Fuelwood	Phone interviews to a representative sample of 5000 households	2006	19 Mt
Marazzi et al., 2006	Fuelwood	Extrapolating at national level the data on the FLA Lombardy regional survey (based on a 32500 household sample using questionnaires)	2006	22.60 Mt
AIEL, 2014	Woodfuels	Calculated based on the residential hearting appliances and boilers capacity	2014	22.25 Mt (19 mt only firewood)
Our estimation on Istat data (2012)	**Fuelwood**	**Calculated based on the expenditure level resulting from the ISTAT "Survey on consumption by families"**	**2012**	**10,50 Mt**

However, before drawing conclusions on the estimation, some considerations on the survey structure with regards to the variable analyzed have to be considered. Firstly, it has to be remembered that the survey was based on information provided by households by compiling an weekly expenses register, So, we can assume that self-consumption (as it doesn't raise any direct costs) is not registered by the households' sample of the survey, but the fuelwood bought through informal market channels might have been included by many households. This is important because it has been showed by the ENEA and FLA Lombardy surveys the self-consumption often accounts for half of the fuelwood consumption. Secondly, it has to also be considered that no information is provided whether only the expenses for firewood are registered or also other woodfuels (pellets and briquettes). This is because the variable does not have sub-categories or specifications fields, and thus it can be considered as an important limitation in the quantity calculation.

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6. A tentative estimation of the production levels based on experts' opinion

In this chapter the results of the Delphi survey questionnaires conducted involving a panel of experts in order to tentatively estimate the production levels of woody biomass in Italy are presented. This Delphi survey was undertaken in two rounds, an approach that enabled us to balance an aimed consensus and also focusing on the individuals' opinion. The preliminary results of the first Delphi questionnaire round are showed in the first section (6.1). In the following section are then presented the final results emerged from the second round, in which the panellists were asked to review the preliminary outcome and revise their estimations on the base of their agreement or disagreement, as in a consensus-process (6.2). At the end, an overview of the results and some considerations are presented.

6.1 Preliminary estimations resulting from the first Delphi round

In the first round of the Delphi survey was asked to the panellists to provide, on the bases informative framework showed (as collected from the literature review in Chapter 4.1) and of their personal knowledge and experience, a preliminary estimation of the internal production from forest and trees outside forest woody biomass harvesting (in the form of value or range of values).

The market flows were based on a simplified market flow chart with four sections: a) Import, b) indirect supply from industry (and post-consumption used wood), c) Energy consumption, and d) Internal production (See Figure 35). So, the estimation was subjected to a constrain, as in an analytic balance:

With this approach the panellists were constrained to provide an estimation of the internal production of woody biomass for energy, taking into consideration also the rest of the market components. Furthermore, this permitted us to analyze specifically the main areas of agreement or disagreement and which are the critical elements of uncertainty and inconsistency.

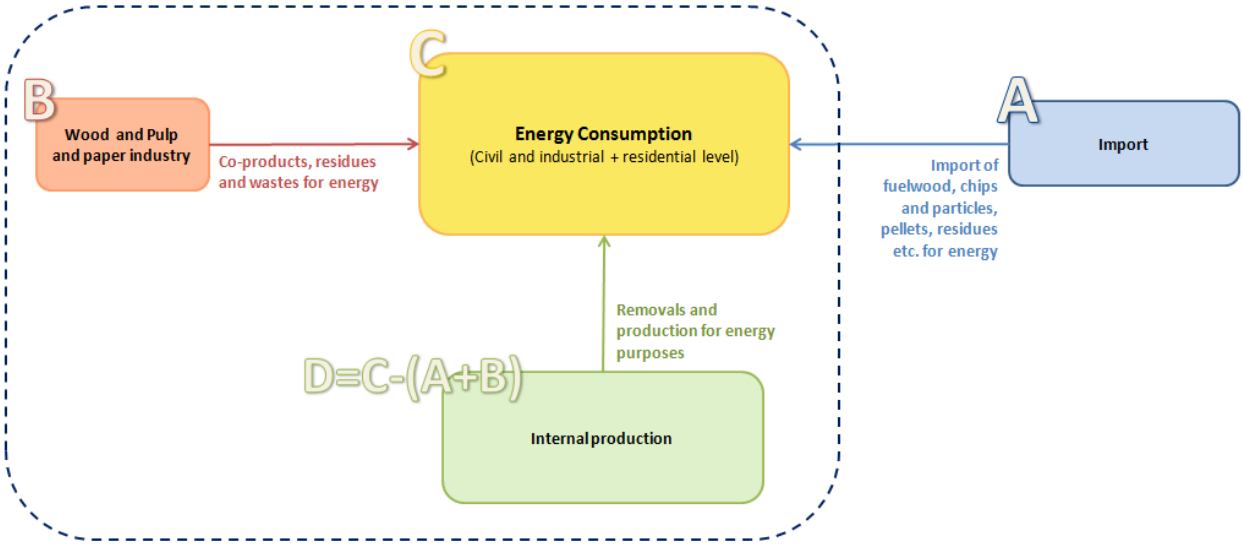
In the following pages the outcome of the first round questionnaires are presented and briefly discussed in the following order:

- Import,
- Indirect supply from industry (and post consumption used wood),

- Energy consumption,
- Internal production.

The results are here represented with the mean, the median, the range of estimates and the standard deviation (σ) to measure the amount of dispersion from the average.

Figure 35: Market flow chart used for the estimation purposes



Import. With regards to the import the results of the first round preliminary estimation by the panel of expert are presented in Table 28.

Table 28: Results from the first round estimate for import

a) Import	
Respondents rate	70%
Mean	4.10 Mt
Median	3.50 Mt
Range (min-max)	2-10 Mt
Standard Deviation (σ)	1.971

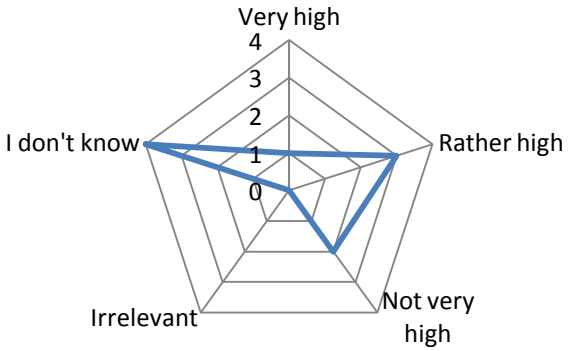
As showed, an estimation was provided by the 70% of the experts, while the other panellists declared not to have enough experience to provide a figure for the import flow of woody biomass for energy. The mean value is 4.10 million tons per year, and the median 3.50 Mt. The range of the estimations provided goes from a minimum value of 2 Mt to a maximum of 10 Mt, with a standard deviation of 1.971.

In the motivations behind the given estimations some important elements have been raised. Romano for instance noted that "*the available data are clearly underestimated, and this is due to the presence of illegal or non-registered import and the lack of an efficient and*

coordinated monitoring and control system. Moreover, it is complex to know the end use of the imported raw material (i.e. chips). Considering these elements, I think it is realistic to increase by a 30% the official values. Based on the FAOSTAT data (the most complete) we would obtain 3.159 Mt". Another expert (expert 1) points that "*for the import we can think about a value two times larger the official one. The underestimation is mainly due to the incompleteness of the basic trade information on which the final value is built. It is likely that import flows from neighbouring EU countries are not registered due to the low levels of control in the free-trade area inside the UE. Moreover, there is a significant quota of not registered biomass import from non-EU countries*". Ciccarese added to these elements that "*the data are likely to be underestimated also because they don't register the quantities of biomass imported to fill biomass burning plants, a phenomena highlighted also by some media*." And finally, Gottero notes that "*there might be an increase in pellets imports and other raw material for energy purposes not registered or registered under different categories (for example wood chips for the use in large scale biomass plants registered as woody compost)*".

In addition, a close-ended question was added to the questionnaire concerning the import: "How important are in your opinion the levels of non-registered woody biomass imported in the Italian internal market?" The responses are showed in Figure 36.

Figure 36: Responses to question 1



As showed they are rather discordant. Four experts said not to know about the situation, three experts consider "rather high" the import of non-registered biomass, two consider it "not very high" and just one as "very high".

Indirect supply. The results concerning the preliminary estimation of the flow of indirect supply of woody biomass from industry (including post consumption used wood) are presented in Table 29.

Table 29: Results from the first round estimate for indirect supply

b) Indirect supply	
Respondents rate	60%
Mean	4.27 Mt
Median	4.50 Mt
Range (min-max)	1.50-7.73 Mt
Standard Deviation (σ)	2.563

The respondents were in this case 60% of the panel group. The mean estimation resulted to be 4.27 million tons, with a median of 4.50 Mt. The range goes from a minimum of 1.50 Mt to a maximum of 7.73 Mt, with a standard deviation of 2.563.

Several points were highlighted in the comments. Hellrigl commented "*that due to the complexity of the value chain and the diversity of production processes, this value is difficult to quantify. However, I think that in average by-product, residues and wastes from the wood processing are about the 20% of the raw material input*". Romano commented that "*this flow is the more difficult to quantify and the information available are not coherent and reliable. However, the current value is in my opinion underestimated of at least a 30%*". Paniz noted that "*the crisis that is affecting the wood processing industry since several years make us think of a relevant reduction also in terms of residues and wastes produced and available for energy use*" motivating a relatively low estimate. Of the same opinion is Gottero, noting that "*the market contraction due to the economic crisis affecting the timber industry in these years affected negatively the amount of residues and wastes available.*" On contrary, Tomassetti, who proposed a higher estimate, motivates that "*a value in the range of 4-6 Mt is reasonable if we include also the woody agro-food industry residues and wastes*".

Consumption for energy: for what concerns consumption of woody biomass for energy the preliminary estimation results are showed in Table 30.

Table 30: Result from the first round for energy consumption

c) consumption	
Respondents rate	70%
Mean	22.16 Mt
Median	22.50 Mt
Range	9-30 Mt
Standard Deviation (σ)	7.249

For this section, the respondents' rate was the 70%. From the individuals estimations resulted a mean estimate of 22.16 million tons and a median of 22.50 Mt. However the range of estimation is very large, from a minimum estimation of 9 Mt to 30 Mt, resulting in a very high

standard deviation of 7.249. Among the motivations, it has been reported by Paniz that "*considering the observed spread of biomass-burning appliances and the growing number of fuelwood selling enterprises, there is for sure a relevant growth in the market, probably also as a decrease of self-consumption*". Moreover it has been highlighted by Romano that *"also in this case the data are evidently underestimated due to the lack of information on residential consumption. In this case, the data provided by AIEL seems the most reliable, although I suppose that the consumption levels of woody biomass are even over 30 Mt/year*". Gottero, in line with the previous comment, explained that "*the large consumers (power plants, CHP etc.) are well monitored, but in some regions there is an important lack of data on household appliances, which often consume more than the double of what official statistics register*". Finally, another expert indicated that "*it is difficult to quantify the consumption based on the personal knowledge and experience. However, even considering the most reliable studies (i.e. AIEL), I think it is not possible at the moment to find an even balance (where demand=supply). It is thus necessary to conduct more detailed surveys on the internal production of fuelwood, on the import and on the real energy produced* "(Expert 1).

Internal production. The estimation of the internal production was the key variable of the survey, derived by the other variables estimations. The results are presented in Table 31.

Table 31: Results from the first round for production

d) internal production	
Respondents rate	90%
Mean	13.96 Mt
Median	12.50 Mt
Range	6-25 Mt
Standard Deviation (σ)	6.736

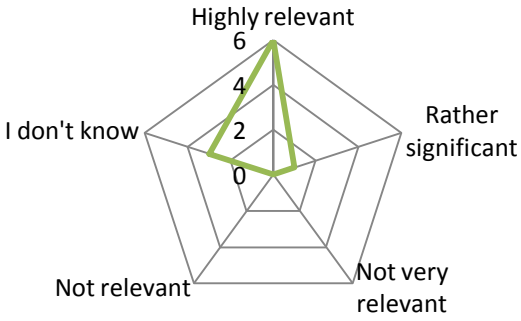
In this case the respondents' rate was the highest (90%). The mean that resulted is 13.96 million tons, with a range of estimations varying between 6 to 25 Mt. The median was of 12.50 Mt and the standard deviation results also considerable high, 6.736.

Interesting elements have been raised in the motivations. Mori explains the official data underestimation in such a way: "*the wood-energy sector is largely unregulated, rich of irregular or* extemporary *market actors operating in local value chains, often not registering their sales. Indeed, many forest owners and operators are also professional agricultural entrepreneurs, getting advantaged with lump sum payments*". Also Gottero marks that "*self-consumption and the informal market plays an important role, at least in the north-western Italian regions. According to some surveys that have been conducted on fuelwood consumption in Piedmont it*

results that the consumption level is about 400% higher than what official data show (the same in Lombardy and Aosta Valley).” Finally, the expert 1 stated that “*the estimated 12 Mm³ (about 6 Mt) should include, beside the official data, the underestimation of fuelwood removals from forests by ISTAT and in addition the outside-forest and non-commercial productions (woody crops, urban forestry etc.) estimated to be about 1 Mt and mainly self-consumed by farmers, land owners etc.*”

Moreover, with specific regards to the production, two closed-ended questions were directly asked to the experts. The first was “How relevant is in your opinion the self-consumption at household level concerning the fuelwood consumption?” The responses are summarized in the radar chart in *Figure 37*.

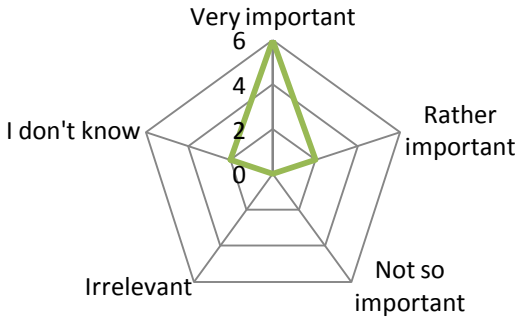
Figure 37: Responses question 2



As showed, the majority of the experts (6) think that the self-consumption is highly relevant in the production. One considers it as rather significant and three do not know about the issue.

The second question was connected to the previous one and was “How relevant is the fuelwood supplied in informal market channels?” Results are presented in Figure 38.

Figure 38: Responses question 3

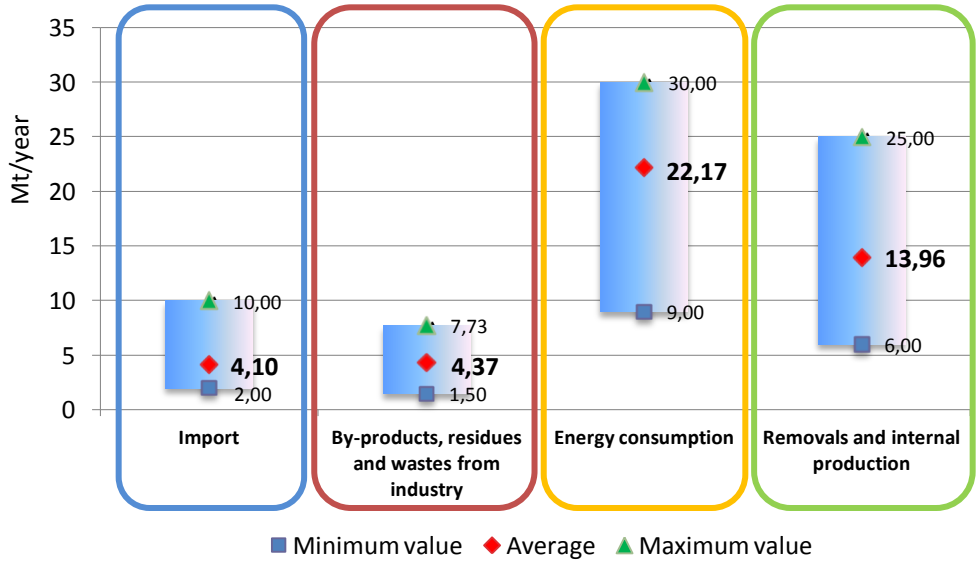


The majority of the experts think that informal market channels play a very important role (6), reflecting what was highlighter also in the comments. Two other experts consider it as rather important and two do not know.

The position of the experts in these two questions shows that the self-consumption and informal market channels are perceived as very relevant in the woody biomass market and thus as major limitations in data collection.

The overall view of the first round preliminary estimations is presented in Figure 39, showing mean value and the range.

Figure 39: Overall estimations and variability resulting from the first round



6.2 Second round outcomes and final estimation of the internal production

The second and final round questionnaire was developed on the outcomes of the first round. The experts, provided with a summary of the results from the preliminary estimations, were asked to review and re-evaluate their estimates on the bases of the resulting mean estimation and were asked to express an agreement or disagreement on the results, and in this last case, revise the estimate as in a consensus process.

The overall final responses are presented in Table 32. The Table is organized in four sections: the first round mean estimation, the number of experts agreeing, disagreeing or not making evaluations, the final mean with the variation from the previous estimates and, finally, the new standard deviation, as a measure of the level of agreement of the panel. As one respondent dropped out from the first round, the participants were nine.

Table 32: Overall results from the second round

	1st round mean estimation	I agree	I don't agree	I don't know	2nd round final mean	Variation from the previous estimate	Standard deviation
*a) I**mport***	4.10	5	3	1	**5.19**	+ 1.09	1.593
b) Indirect supply from industry (and post consumed wood)	4.37	6	2	1	**3.78**	- 0.59	1.097
c) Energy consumption	22.16	5	1	3	**21.20**	- 0.97	2.367
*d) I**nternal production***	13.96	7	2	0	**12.91**	- 1.05	2.637

Import. For what concern the import, five expert (out of nine) agreed with the mean estimate resulting from the first round, one did not express any opinion, and three disagreed. All the three experts disagreeing with the first round mean of 4.10 million tons, revised the estimate increasing it, resulting in a new mean of 5.19 Mt (thus +1.09 Mt from the first). The standard deviation was then 1.593, slightly lower than in the first round, when was 1.971. Among the motivations of the experts increasing the estimation, Paniz proposed an estimation of 8 Mt noting that "*the high consumption levels estimated presume also high import levels*". Romano, reporting 7 Mt as quantity of imported woody biomass, added that "*in my opinion the import levels might be even higher*".

Indirect supply from industry (and post consumption used wood). Concerning indirect supply, six experts agreed, one did not express any opinion and two disagreed, both reducing the estimation of 4.37 resulting from the first round. The new estimate resulted thus in 3.78 million tons, -0.59 from the previous, with a standard deviation of 1.097, compared to the previous of 2.563. The two experts disagreeing, Paniz and Gottero, proposed both an estimate

of 2 Mt, motivating that the recent economic crisis that has affected also the wood-processing industry is inevitably resulting in a decrease of wastes and residues available for energy.

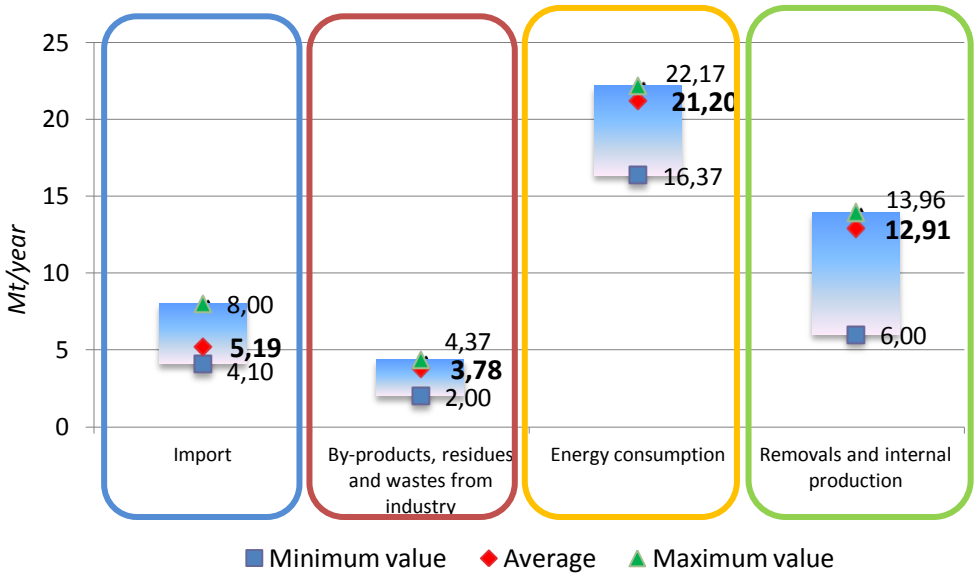
Energy consumption. With regards to woody biomass consumption for energy, five panellists agreed with outcomes of the first round of 22.16 million tons of consumption. Three did not express any opinion and just one disagreed (expert 1), revising the estimate to 16.37 Mt. The new estimate resulting from the second round is thus 21.20 Mt, -0.97 compared to the previous estimate. A new standard deviation of 2.367, significantly lower than the previous of 7.249, showing a rather high level of agreement among the experts. Tomassetti, although agreeing with the estimated wrote that "*concerning the consumptio, n this result is the value of the estimations made 15 years ago. Since then, the self-consumption is maybe the same, but it is evident that the fuelwood market is more organized and has grown, thus also the fuelwood consumption should have grown since then. There is then the issue of the calorific value, low for wood chips (2000 Cal/kg), medium for firewood (3000-3300) and high for pellets (4400), and this has to be taken into consideration in an energy balance".*

Internal production. Finally, for what concerns the key variable of internal production, all the experts involved expressed an opinion. Seven agreed with the previous estimate of 13.96 Mt while two disagreed, both lowering the mean estimate. The new estimate is 12.91 Mt, -1,05 compared to the first round, with a standard deviation of 2.637, also here considerably reduced from the previous of 6.736. One of the two experts (Mori) was disagreeing and suggested "*reducing the values of the internal production. If we consider the maximum from the range resulted from the experts' opinion (25 Mt), this represent the 85% of the annual increment and considering that there are many protected areas where utilizations are limited, the value is clearly too high. Assuming as an example the data on forest removals in Piedmont and Tuscany and extrapolating them at national level we obtain 12.5 Mt. Even though, we have to consider that there are some regions (as Basilicata and Sardinia) with a large forest cover but with a very low utilization rate. Thus even 12.5 Mt is substantially an overestimation. However I leave this as a new estimate as I don't have other elements to quantify the utilization rate of these regions*." The second expert (Expert 1) commented that *"is not an easy matter to quantify these elements. Even harder is to find a balance among the market fluxes (production=consumption-(import+indirect supply from industry), and surely is not possible to attributing to the internal production such a high value (probably obtained with an analytical subtraction, giving the priority to the estimation of the consumption, which is reasonable). Thus, I stress the fact that the*

internal production can be at maximum 6 Mt (which would be the 100% more of the current ISTAT data)"

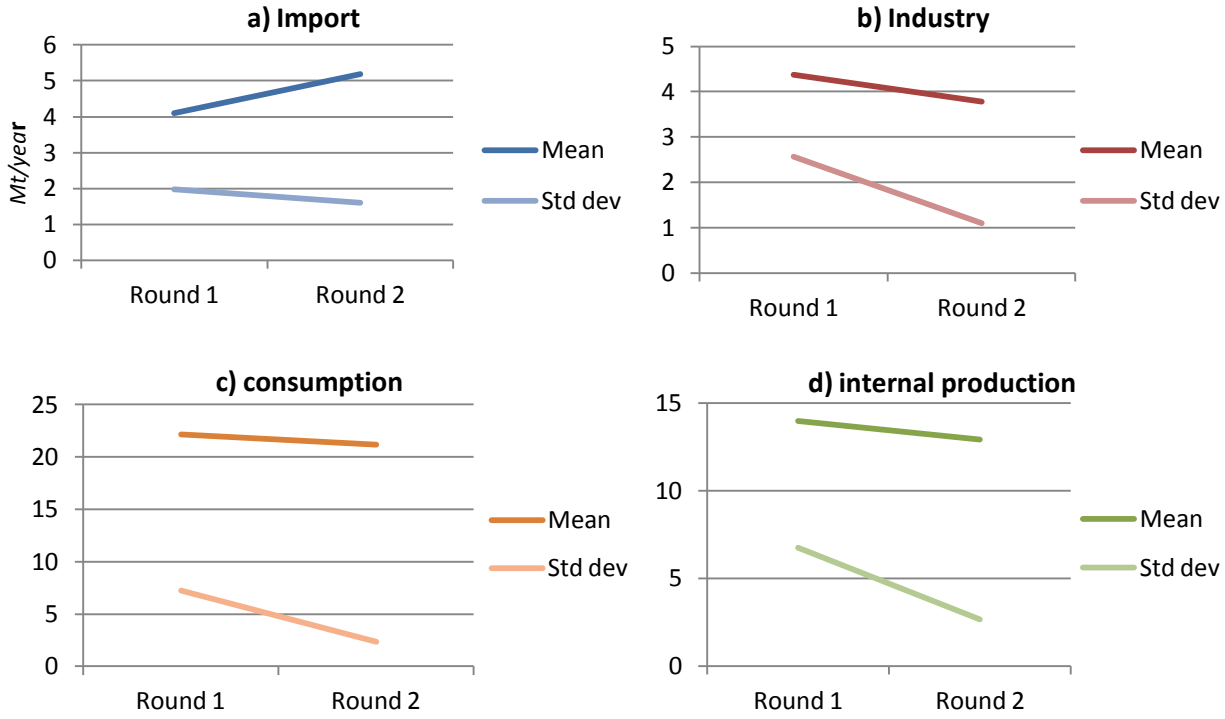
The overall results are showed in Figure 40, as for the first round estimate the new mean and range of difference of opinions are presented. As can be observed, the range of estimations is relevantly reduced for all four the sections, especially for what regards indirect supply from industry and consumption, while the variability is still rather high for import and internal production. However, it has to be remembered that it is usual in a Delphi survey where, in each succeeding round, the range of responses by the panelists normally decreases, and thus the variability indicators.

Figure 40: Overall estimation and variability resulting from the second estimation



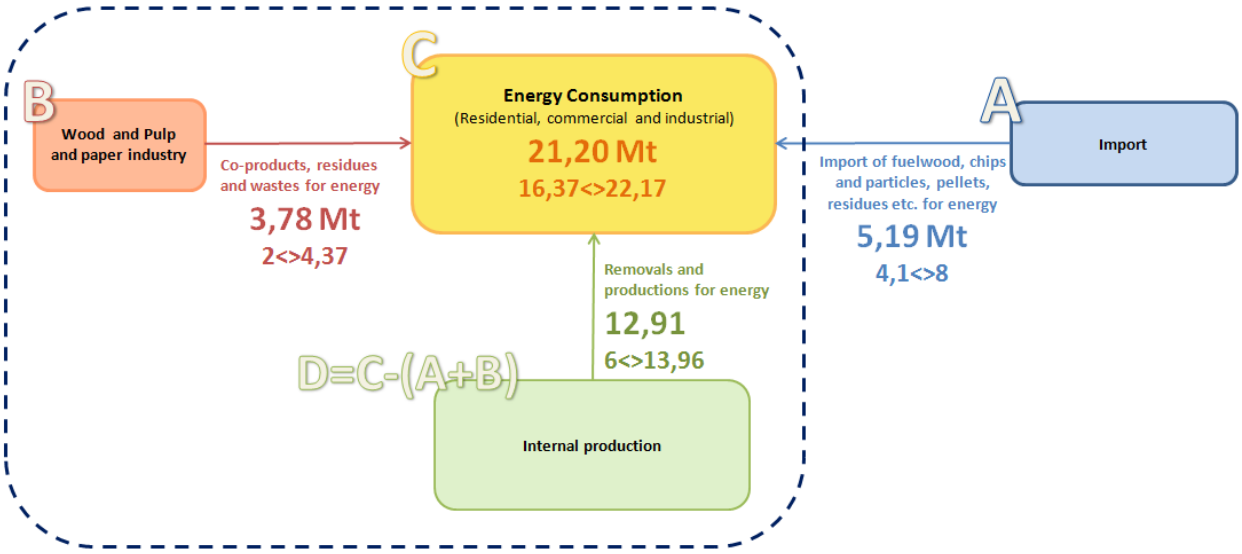
A further analysis to facilitate a comparison of the changes of the experts' opinion (mean) and the level of agreement (standard deviation) of the panel from the first to the second round is presented in Figure 41. As previously presented, the only mean estimate that increased from the first to second round is the import flow, but its standard deviation did not diminish significantly. For the other three sections the mean estimate decreased slightly from the first to the second round, and the standard deviation decreased considerably, especially with regards to consumption and production.

Figure 41: Comparison of experts' opinion changes from the first to the second round



Overview of the results and discussion. Figure 42 presents the entire picture of the market flow chart as resulting from the two rounds of the Delphi survey in which the experts were asked firstly to provide a preliminary estimation based on their knowledge and experience and then, in the second round, to review and revise their opinions on the basis of the outcomes from the whole panel. Considering a margin of 0.68 Mt due to the revision process, the results show a consumption level of woody biomass for energy in Italy of 21.20 Mt (varying between 16.37 and 22.17 Mt), deriving for 12.91 Mt from the internal woody biomass harvesting in forest areas and outside the forests (range 6-13.96 Mt), 5.19 Mt from the import (rage 4.1-8.0 Mt) and finally 3.78 Mt from the indirect supply of wastes and residues from the industry (including post-consumption used wood) (range 2.0-4.37 Mt).

Figure 42: Market flow resulting estimation



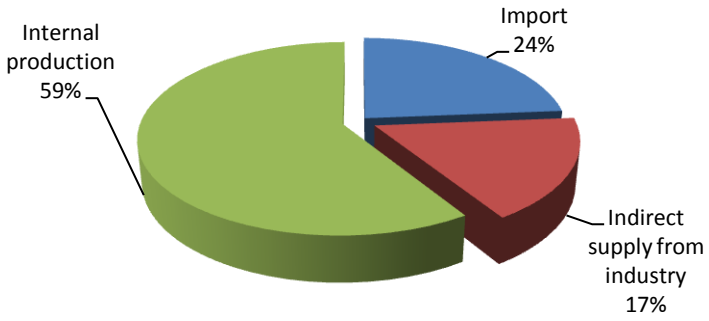
On the basis of these results some considerations can be drawn:

- A clear discordance in the individual preliminary experts' estimates emerged, confirmed by the high variability in the range values (2-10 Mt for import, 1.50-7.73 Mt for indirect supply, 9-30 Mt for consumption and 6-25 Mt for internal production) and the high standard deviation for all the four flows. This demonstrates the uncertainty in quantifying the wood-energy market data.
- A reasonable level of consensus has been reached in the estimation of the indirect supply from industry (and post consumption used wood) and energy consumption, showing that a better quantification of these two flows has been reached. With regards to the indirect supply from industry, this emerged as the most complex flow to quantify and with less (or more dispersed) information. However, probably also due to the relying of the experts on the only two estimations available (by ITABIA, 2008 and ENAMA, 2011), the level of agreement in the second round was rather high (standard variation from 2.563 to 1.097). Concerning the consumption, a good level of consensus (considering the large variability emerged in the preliminary results) has been reached in the second round (with a significant reduction of the standard deviation from 7.249 to 2.367). Anyway, it has also to be noticed that the respondents' rate was the lowest in this section (70% in the first, and 66% in the second round).
- On the contrary, import and production showed the highest standard deviation (and less relevant decrease from one round to the other) and so the lowest level of consensus among the experts, as a demonstration of the complexity of the issue. Concerning the

import, this resulted to have a high variability both in the first and in the second round. Indeed, the relatively high standard deviation (1.971 in the first round and 1.593 in the second), shows a very low level of agreement. Concerning the internal production flow, an adequate level of consensus has been reached around the mean estimation resulting from the first round (standard deviation from 6.736 to 2.637), although the range of variability was still high.

- In any case, it results from the experts' opinion that, as a consequence of the high consumption levels, the internal production plays a major role and that official statistics quantify this variable only partially. If we translate the supply flows resulting from the Delphi survey in percentage, it results that the large part of the woody biomass consumed is considered by the experts to come from the internal woody biomass harvesting from forest and outside forest areas (59%), while 24% from the import and a 17% from the industry (see Figure 43).

Figure 43: Supply of woody biomass in percentage



It is interesting to make a comparison of the survey results with the official data and other estimations available, as presented in Chapter 4.1.1 (see Table 33).

Table 33: Comparison between the survey results and other production data

Source	Categorization	Data/Estimate
ISTAT (2011)	Fuelwood removals from forest and outside forest areas	5,388,488 m³ (2,694,244 t)
Gasparini e Tabacchi, 2011	Fuelwood and industrial roundwood removals	13,300,000 m³ (6,650,000 t)
NREAP progress report 2013	Direct supply of wood biomass from forest and other wooded land for energy generation	8,350,500 t
JWEE (UNECE/FAO, 2013)	Fuelwood from forest and outside forest areas	19,643,000 m³ (9,821,500 t)
Experts' estimation	Woody biomass harvested from forest and Outside forest areas	12,910,000 t

As previously discussed, the data from ISTAT (2011) of 5,388,488 cubic meters (resulting in 2,694,244 tons using the Mantau *et al.*, 2010 coefficient) results to be clearly underestimated if compared to what all the other data and estimation shows. In any case, the expert's estimation of 12.91 Mt is considerable higher than what other figures show. Even so, an important element stressed by some experts is that if 12.91 Mt of internal production are translated in cubic meters with the coefficient already used in this work (Mantau *et al.*, 2010), it results in nearly 25.82 Mm³, which is the 70% of the mean annual increment reported by the INFC in 2005, only for woody biomass for energy. This value could be considered too high assuming that the INFC data on are not referred to the Net Annual Increment (i.e. the total increment less the removals), but to the increment before the harvesting operations. Unfortunatly, this is still an open issue and the INFC data are not a clear reference for a consistency analysis.

To conclude, this exercise showed that it is really complex at the moment to define all the flows and quantify a clear market balance (where demand is equal to supply). Moreover, it has to be remembered that the existence of a consensus among the experts does not necessarily mean the correctness and solidity of an estimate. However, the real significance of this tentative estimation was to identify the likely range of values and the most important critical barriers to a consistent quantification.

7. A comparative analysis between Italy and Spain

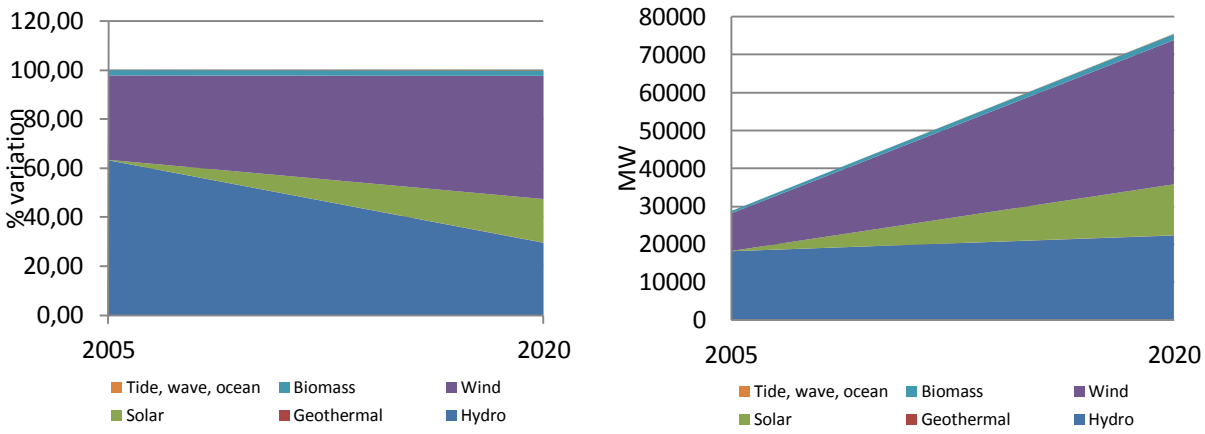
In this chapter, a comparative analysis of the current state of the wood-energy market in Italy and Spain as resulting from the main informative sources is presented. In the first part (7.1), in order to see and compare the role that bioenergy has in the two countries and in their renewable energy strategies towards 2020, we will briefly discuss the Spanish NREAP and compare it with the Italian one (presented in Chapter 2.2.1). In the second part (7.2) we will make an overall comparison based on the main official and non-official informative sources available in the two countries and draw some consideration on data quality and consistency.

7.1 The Spanish NREAP and the role of bioenergy in comparison with Italy

The main framework related to the use of bioenergy in Spain is the National Renewable Energy Action Plan (NREAP), adopted by the Spanish parliament in November 2011 to implement the EU Renewable Energy Directive 2008/28/EC. The target for Spain is to cover by 2020 the 20% of its final energy consumption with RES - the same as the EU average - together with a contribution of 10% from RES in the transport sector. In 2009, renewable energy in Spain accounted for 9.4% of the primary energy supply and around the 12% in terms of gross final energy consumption (MINIETUR, 2011).

The Spanish renewable energy expected developments towards 2020 and the contribution are showed - as we did for Italy - in the following two graphs. In Figure 44, the share of electricity produced from RES in 2005 and the forecast for 2020 are presented; in the left side graph the percentage contributions of the different RES is reported and in the right side graph the developments in absolute terms. As showed, biomass accounted in 2005 for the 2.10% of the electricity generated from RES, the percentage of contribution will not change by 2020, although in absolute terms electricity produced from biomass will double, growing from 604 MW to 1,587 MW (of which 1,187 MW of solid biomass). A much larger importance is given to solar power, a contribution that will grow from 0.21% to 17.80%, and wind power, from 34.44% to 50.30% of the renewable electricity share.

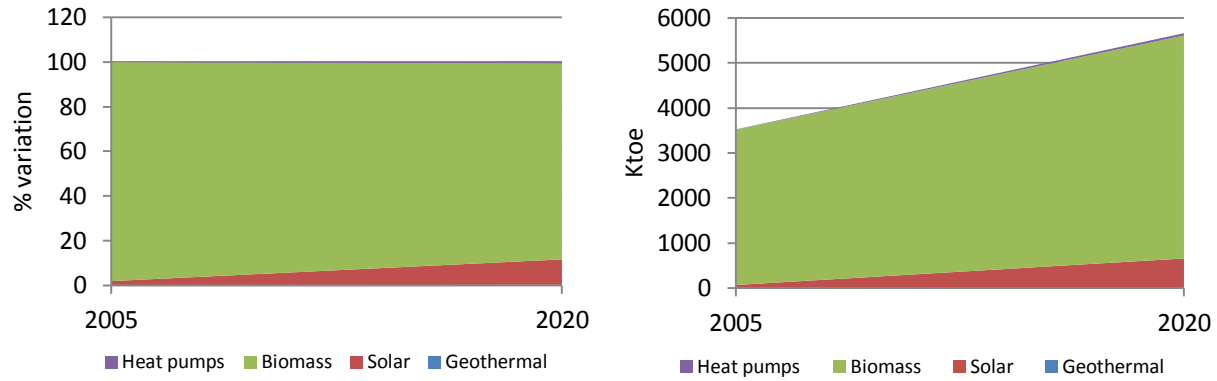
Figure 44: Electricity from RES according to the Spanish NREAP



Source: MINIETUR, 2011

The contributions of the different sources to the RES heating and cooling share are presented in Figure 45. Again, the percentage contribution is showed in the first graph, while in the second one the developments in absolute terms are reported.

Figure 45: Heating from RES according to the Spanish NREAP



Source: Spain NREAP

As can be observed, biomass accounted for almost the totality (97.94%; 3,447 Ktoe) of the heating generation in 2005. By 2020 is expected a slight diversification of the energy sources, although biomass will still play the dominant role (87.54%), with an increase in absolute values to 4,950 Ktoe (4,850 from solid biomass).

In the following table (Table 34), a comparison of the role of bioenergy in the NREAP strategy toward 2020 between Spain and Italy is presented.

Table 34: The role of bioenergy in the Italian and Spanish NREAP

	Electricity				***Heating***			
	2005		*2020*		*2005*		*2020*	
	%	MW	%	MW	%	Ktoe	%	Ktoe
Spain	2.10	604	2,10	1,587	97.94	3,447	87.54	4,950
Italy	8.30	1,990	19,82	4,650	84.99	1,655	57.99	5,520

Source: NREAP

For what concern the electricity generated from RES, it can be observed that Italy gives more importance to biomass; already in 2005 it was accounting for the 8.30% of the share (1,990 MW), and its expectation for 2020 is to account for the 19.82%, amounting at 4,650 MW, almost three times more what is expected in the Spanish plan. With regards to the heating sector, it results from the NREAP data that in 2005 Spain was relying more than Italy on biomass (3,447 ktoe against 1,665 Ktoe). On the contrary, the expected increase by 2020 will bring the two countries to very close values (4,950 Ktoe for Spain and 5,520 for Italy), in terms of contribution the heating with RE pool is larger in Spain (87.54% against 57.99%) although Italy aims at larger absolute numbers.

The data in the Spanish PER technical study. In addition to the NREAP, the Ministry of Energy, Tourism and Trade (MINIETUR) and IDAE carried out the Renewable Energy Plan (PER) to assess and evaluate the expected developments until 2020 for the RES, including surveys on technological developments, resources availability, and economic competitiveness (IDAE, 2011). This has been done also for biomass resources, where a study on resources availability has been conducted using spatial analysis tools. The following tables shows the main results of the technical study with regards to biomass, presenting the biomass availability in Spain and the biomass calculated to be needed to fulfill the 2020 targets.

The biomass potential and the consumption in 2006 are reported in Table 35. As can be observed, the study showed a potential availability of woody biomass from forests (full tree and harvesting residues) of 18,715,486 tons per year, 6,598,861 t/year of “wooden mass potentially in agricultural land” and 15,072,320 t/year of “other wooden mass potentially available in forest land”.

Table 35: Biomass potential in Spain according to the PER

Origin		Potential (t/year)	Consumption in 2006 (t/year)
Forest biomass	Wood harvesting residues	2,984,243	5,545,287
	Full tree	15,731,116	
Agro biomass	Herbaceous residues	14,434,556	478,011
	Wooden residues	16,118,220	1,912,046
Herbaceous mass potentially available in agricultural land		17,737,868	0
Wooden mass potentially available in agricultural land		6,598,861	
Other wooden mass potentially available in forest land		15,072,320	
Total biomass potential		86,677,1930	7,935,343

Source: IDAE, 2011

In the context of this thesis is more interesting to analyse Table 36, where the calculations for the biomass needed to fulfil the 2020 targets, dividing by origin and final user, are presented.

Table 36: Biomass needed for 2020 targets according to the PER

Tons/year	Pure power plants		CHP	
	Available	Needed	Available	Needed
Forestry (full tree)	391,462	1,978,308	0	540,255
Herbaceous mass potentially available in agricultural land	6,640,089		0	
Wooden mass potentially in agricultural land	0		0	
Agricultural herbaceous residues	2,876,476		793,743	
Agricultural wooden residues	9,652,772	1,658,164	0	257,102
	5,147,870		0	
Wooden industries biomass	430,173	1,872,222	0	411,703
Total	24,958,842	5,508,698	793,743	1,209,060

Source: IDAE, 2011

A total biomass needed to fulfil the 2020 target for power plants of 5,508,698 tons per year (solid biomass) and 1,209,060 for cogeneration plants are reported in the table.

In Italy, ENEA carried out a similar study (*Atlante biomasse*; ENEA, 2008) with a specific focus on biomass from residues and wastes from agriculture and agro-food industry. In addition, by the time this thesis, ENEA was conducting a new study on biomass availability in Italy aiming at developing a map; however the results are not yet available.

The data in the Member States Progress Reports of 2013. It is interesting also to take a look at the data from the Member States Progress Report under the Directive 2009/28/EC published in 2013 by both Italy and Spain, following the same template prepared from the EC and the methodology organized by Eurostat (MINIETUR, 2013).

The table concerning the biomass resources use for Spain is showed in Table 37; that one for Italy in Table 15.

Table 37: Biomass for energy supply in Spain according to the 2013 NREAP progress report

	Amount of domestic raw material (*)		*Primary energy in domestic raw material (toe)*		*Amount of imported raw material from EU (*)*		*Primary energy in amount of imported raw material from EU (ktoe)*		*Amount of imported raw material from non EU(*)*		*Primary energy in amount of imported raw material from non EU (ktoe)*	
	2011	***2012***	***2011***	***2012***	***2011***	***2012***	***2011***	***2012***	***2011***	***2012***	***2011***	***2012***
Biomass supply for heating and electricity:												
Direct supply of wood biomass from forests and other wooded land energy generation (fellings etc.)	6,449,761	6,119,989	1,612	1,530	0	0	0	0	0	0	0	0
Indirect supply of wood biomass (residues and co-products from wood industry etc.)	6,418,614	6,264,771	1,926	1,879	0	0	0	0	0	0	0	0
Energy crops (grasses, etc.) and short rotation trees *(*please specify*)*	769,843	1,072,727	237	322	0	0	0	0	0	0	0	0
Agricultural by-products / processed residues and fishery by-products	5,757,227	5,620,115	2,035	1,939	-	-	-	-	-	-	-	-
Biomass from waste (municipal, industrial etc.)	7,110,385	7,201,425	529	498	-	-	-	-	-	-	-	-
Others (please specify)	-	-	-	-	-	-	-	-	-	-	-	-

(*) Amount of raw material if possible in m3 for biomass from forestry and in tonnes for biomass from agriculture and fishery and biomass from waste

Concerning the availability and use of biomass resources for energy purpose in 2012 in Spain and Italy, the main observations are:

- For the internal production ("amount of domestic raw material"), the report shows for Spain a direct supply of woody biomass from forest and other wooded land of 6,119,989 cubic meters in 2012. In Italy the report presents the figure of 8,350,500 tons in 2012, that converted in cubic meters (Mantau *et al.*, 2010) result in 16,701,000 m³, corresponding to almost three times the Spanish figure.
- The indirect supply ("indirect supply of residues and co-products from wood industry etc."), is showed for Spain to amount at 6,264,771 m³ in 2012, and biomass from energy crops and SRF at 1,072,727 m³ in 2012. In Italy similar order of magnitude apply for indirect supply and SRF, whereas in Spain indirect supply by far exceeds (six times more) the SRF.
- Concerning the import and export, according to the report, it should not be any trade of biomass for energy in Spain. In Italy, this is showed to be 1,220,713 tons in 2012 of forest woody biomass and 1,654,829 tons/year of indirect woody biomass from industry.

7.2 Comparison of main variables of the wood-energy market between Italy and Spain

In the following pages a comparison of the main variables of the wood-energy market between Italy and Spain will be presented, according to official and non-official informative sources at national and European Union level.

7.2.1 Internal production from forest and outside forest

In Spain, as in the majority of European countries, most of the biomass sources used for energy generation comes from the forestry sector. Concerning the data on forest utilization, these are provided at national level by the Ministry of Agriculture and Environment (*Ministerio de la Agricultura y Medio Ambiente* – MAGRAMA) and by the National Institute of Statistics (INE). Moreover, we can find data on fuelwood removals also in international agencies data banks such as FAOSTAT and UNECE. The data are presented in Table 38.

Table 38: Forest utilization data in Spain according to different sources

Source	Reference year	Removals from forest (m^3)		
		Fuelwood	Timber for industry	Total
MAGRAMA	2010	5,120,000	10,969,000	16,089,000
INE	2010	2,445,000 (t)		
UNECE, 2013	2010	5,120,000		
FAOSTAT, 2012	2010	5,120,000		

As showed in the table, the data on fuelwood removals used in by the various informative sources are the ones provided by MAGRAMA. For 2010 (taken as a reference year because it was the last published by INE) the fuelwood removals are recorded to be 5,120,000 cubic meters. The only difference for the INE is that it shows the forest utilization figures in tons, reporting a 2,445,000 tons of fuelwood removals in the same year, however, depending on the conversion factors used the data approximately equal.

More interesting is to see the fuelwood removals for three consecutive years (2009, 2010 and 2011) as provided by MAGRAMA. These are presented in Figure 39 and, as it can be seen, the inter-year variability is considerably high, going from 2,080,000 cubic meters of fuelwood removals in 2009, to a double figure in 2010 (5,120,000 m^3), and 3,900,000 m^3 in 2011, the last year for which the data are available (MAGRAMA, 2011).

Table 39: Fuelwood removals in Spain in 2009, 2010 and 2011

Source	Fuelwood removals from forest (m^3)		
	2011	2010	2009
MAGRAMA	3,900,000	5,120,000	2,080,000

Source: MAGRAMA

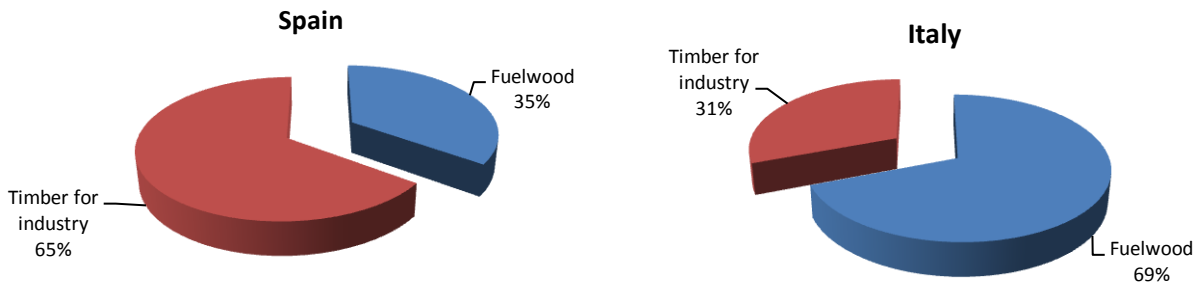
If we compare Italy and Spain, an important structural characteristic that differentiate the two countries emerges. The data on removals, as provided by the two official sources, ISTAT for Italy and MAGRAMA for Spain, are presented in Table 41.

Table 40: Fuelwood removals between Italy and Spain

Source	*Reference year*	*Fuelwood removals (m^3)*	*Timber for industry (m^3)*
ISTAT	2011	5,084,000	2,262,065
MAGRAMA	2011	3,900,000	10,969,000

In 2011, which is the last year in which these data were available, ISTAT registers 5,084,000 m³ of fuelwood removals (65% of the total) and MAGRAMA for Spain 3,900,000 m³, corresponding to the 26% of the total removals. Beside the figures in absolute terms, it emerges that in Italy the large part of the removals from forests are for energy purposes, while in Spain fuelwood removals, by anyhow lower than the Italians, are a minor part compared to the timber for industry removals, as showed in Figure 46.

Figure 46: Forest utilization in Spain and Italy



Data: ISTAT and MAGRAMA

For what concerns other woodfuels production (wood chips and pellets), data are provided by the MAGRAMA, and again sent to and published by FAOSTAT. The same in Italy where ISTAT is the source of the FAOSTAT data. The data for 2011 and 2012 are showed in Table 41.

Table 41: Chips and pellets production in Spain and Italy

Source		Reference year	Production	
			Chips (m³)	Pellets (t)
Spain	***MAGRAMA***	2012	1,541,425	
	FAOSTAT	2012	1,541,425	250,000
Italy	***FAOSTAT***	2012	1,096,000	300,000
	Eurostat	2011		816,000

In Spain 1,541,425 cubic meters of chips were produced in 2012 according to MAGRAMA, a figure reported also by FAOSTAT (2012). For the pellet production, in 2012 a figure of 250,000 tons has been recorded. The Spanish sectorial agency BIOPLAT reported the pellet production to be in 2013 at 250,000 tons; this corresponds to about the 25-30% of the domestic pellet production capacity.

In Italy the production of wood chips according to FAOSTAT is slightly lower, 1,096,000 m³ in 2012, while with regards to pellets production, as explained in Chapter 4.1, more discrepancies are present. FAOSTAT registers for 2012 a production of 300,000 tons of pellets while Eurostat, with 2011 as reference year, 816,000 tons. However, also driven by the higher consumption, production of pellets is clearly higher in Italy.

Concerning the woody biomass available from outside forest areas, no specific data are found for Spain. For instance, no data are available at national level on the woody biomass from urban forestry activities, as these waste and residues management is regulated at municipal level, varying depending on the local context.

With regards finally to the woody biomass from agriculture and agro-food industry, it is known that this plays and important role in Spain, in particular the olive use of olive stones from the large olive orchard in Andalucía and South Spain. However, no quantitative data on the amount of raw material employed can be found, but only energy production data (showed in the energy consumption section).

7.1.2 Import and export

Concerning trade data, for Spain these are again provided by MAGRAMA. In Table 42 we can compare the data on import as provided by different sources like MAGRAMA, FAOSTAT, Eurostat and UNCOMTRADE.

Table 42: Import of Spain according to different sources

Source	Reference year	Import			
		Chips (m³)	Fuelwood (and charcoal) (m³)	Pellets (t)	Waste and residues (m³)
MAGRAMA	2011	923,969	5,000		74,119
FAOSTAT	2011	924,000	4,777		
	2012		8,538	16,316	
Eurostat	2012		8,540		
UNCOMTRADE	2012	685,687 (t)	3,461 (t)		54,255 (t)

As can be observed, MAGRAMA provides data on chips, fuelwood and wood residues import, showing for 2011 (last year in which data were available) an import of 923,969 cubic meters of chips, 5,000 m³ of fuelwood and 74,119 m³ of waste and residues. The same data are showed also by FAOSTAT, which in addition reports for 2012 an import of pellets of 16,316 tons

and fuelwood of 5,538 m³, same figures as those by Eurostat. Finally, as in the case of Italy, the UNCOMTRADE data differs as they are provided in tons and not in cubic meters.

In comparing trade data on import between Italy and Spain according to the international trade database, important differences emerge. The comparison is reported in Table 43.

Table 43: Import of woodfuels in Italy and Spain

Source		Reference year	Import			
			Chips (m³)	Fuelwood (and charcoal) (m³)	Pellets (t)	Waste and residues (m³)
Italy	***FAOSTAT***	2012	844,000	991,463	1,197,000	623,000
Spain	***MAGRAMA***	2011	923,969	5,000		74,119
	FAOSTAT	2012			16,316	

The level of import of wood chips is the same for the two countries, while when comparing fuelwood, pellets and wood residues, an important difference emerges among Italy and Spain. While Italy shows very high levels of import, according to FAOSTAT (2012) of 991,460 m³ of fuelwood, 623,000 m³ of wood waste and residues and finally 1,197,000 tones of pellets, in Spain the import of these three commodities is almost irrelevant.

A comparison can also be done concerning the import based in UNCOMTRADE data (see Table 46).

Table 44: Import comparison according to UNCOMTRADE

Source	Reference year	Wood biomass import			
		Chips (t)	Fuelwood (and charcoal) (t)	Pellets (t)	Waste and residues (t)
Italy	2012	434,679 (t)	720,448 (t)		1,900,710 (t)
Spain	2012	685,687 (t)	3,461 (t)		54,255 (t)

Source: UNCOMTRADE

For the export data, again for Spain, according to the MAGRAMA source, an export of 20,000 cubic meters of chips in 2011, of 59,000 m³ of fuelwood and 283,000 m³ of waste and residues are recorded. It is interesting to see that in the following year, when MAGRAMA data were not available anymore, FAOSTAT and Eurostat reported the same values for chips (128,206 m³) and fuelwood (111,270 m³) export.

Table 45: Export of Spain according to different sources

Source	Reference year	Wood biomass export			
		Chips (m^3)	Fuelwood (and charcoal) (m^3)	Pellets (t)	Waste and residues (m^3)
MAGRAMA	2011	20,000	59,000		283,000
FAOSTAT	2012	128,208	111,270	70,734	
Eurostat	2012	128,206	111,270		291,020
UNCOMTRADE	2011	20,279 (t)	55,973 (t)		286,112 (t)

Comparative data are shown in Table 46. As can be observed, on contrary of the import values, Spain has significant levels of exports, while in Italy all the production is consumed in the domestic market.

Table 46: Export data for Italy and Spain

Source		Reference year	Wood biomass export			
			Chips (m^3)	Fuelwood (and charcoal) (m^3)	Pellets (t)	Waste and residues (m^3)
Italy	*FAOSTAT*	2012	2,000	3,060	5,000	14,516
Spain	*MAGRAMA*	2011	20,000	59,000		283,000
	FAOSTAT	2012	128,208	111,270	70,734	

7.1.3 Indirect supply

For what concern the indirect supply from industry and post consumption used wood, making reference to the same categories as we did for Italy, the data provided by MAGRAMA shows an amount of wood waste and residues of 2,113,469 in 2011, a figure reported also by FAOSTAT. The data for last three available years are presented in Table 47.

Table 47: Wood waste and residues production in Spain

Source	Wood waste and residues (m^3)		
	2011	2010	2009
MAGRAMA	2,113,469	1,886,847	2,580,000

Source: MAGRAMA

In Italy, FAOSTAT reports a figure of 904,000 m^3 for 2012, although some recent studies showed that the availability is higher (ENAMA, 2011). The higher amount of wood waste and residues registered in Spain is reasonable if considering the much higher levels of industrial

roundwood removals and consequently a higher volume of residues after the processing operations.

With regards to the post consumption used wood, interesting data are provided by the Spanish Association for Wood Recycling (ASERMA), a consortium of associations managing post-consumption used wood from furniture, carpentry, packaging, pallets etc. The association was active only until 2013. If we look at the last data available, it results that in 2007 the amount of post-consumption used wood managed by the association was 748,000 tons and in 2008 528,000, and then is reported to be around 500,000 tons until 2012. In 2009 it is specified that the 36% of the amount of post-consumption used wood used collected was used for energy generation. Another informative source on post-consumption used wood is the INE that shows a figure of 1,745,440 tons of “recycled wood” in 2012, although it does not specify the amount used for energy generation (INE, 2013). In Italy, as previously explained, this figure is provided by the consortium for the recycling of wood packaging material Rilegno, reporting a volume of wood packaging material recycled of 2,163 thousand tons for 2013. Out of this amount, 80 thousand tons are used for energy production, the 3.63% (Rilegno, 2013).

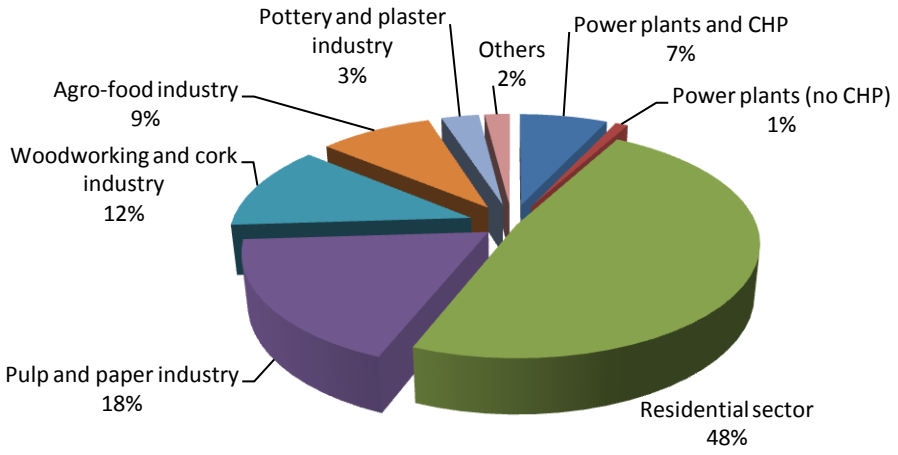
7.1.4 Energy consumption

In Spain the use of woody biomass for energy is strongly related to the forestry and agro-forestry based industry and for some extent also the ceramics industry, but also the household consumption plays a relatively important role, mostly in traditional heating appliances as fireplaces or firewood-burning stoves. On the basis of the literature review conducted, no specific data or information concerning the quantities of woody biomass employed for energy generation are available in Spain. However, data are available in energy statistics, mainly expressed in tons oil equivalent.

In 2012 IDAE reported a consumption of woody biomass for heating and cooling of 3,851 Ktoe, of which 2,485 Ktoe for residential heating. The household consumption is more spread in Northern Regions (Castile and Leon, Catalonia and Galicia) with the exception of Andalucía. Interesting is to look at the distribution of energy consumption from biomass (inluded non-wood biomass) in the different sectors and by final users. According to IDAE the data are showed in Figure 47. As showed, the residential sector is the in the largest consumer of woody biomass (48%). However the forest-based industries have an important role too; the pulp and paper industry consume the 18% of bioenergy, the wood processing industry (including cork) the 12%.

The agro-food industry the 9%, the power plants and CHP an 8 % in total, and finally the pottery and plaster industry the 3%.

Figure 47: Biomass consumption in Spain by sector and end user



Source: IDAE

A comparison with Italy can be done on the basis of the data expressed in energy units of measurements from national and international agencies. A comparison showing the primary energy production from solid biomass (also here not only woody biomass) in the heating and cooling sector and in electricity generation according to AEBIOM, Eurostat and EurObserv'er is presented in Table 48.

Table 48: Primary bioenergy production in Italy and Spain

	Source	Heating and cooling (Ktoe)	Electricity (Ktoe)	Total (Ktoe)	Energy consumption (Ktoe)
Spain	***AEBIOM 2011***	3,775	1,150	4,925	
	Eurostat 2011			4,818	
	EurObserv'er 2011			4,812	4,812
Italy	***AEBIOM 2011***	3,707	869	4,576	
	Eurostat 2011			3,953	
	EurObserv'er 2011			3,914	5,127

As can be observed from the table, the data on primary energy production are more homogeneous in the case of Spain. With 2011 as reference year, AEBIOM report an energy

production in heating and cooling of 3,775 Ktoe and 1,150 Ktoe in the electricity generation, for a total of 4,925 Ktoe, close tot he values presented by Eurostat and EurObserv'er. In the case of Italy AEBIOM reports a value of 3,707 Ktoe in heating sector and 869 Ktoe in the electricity generation, for a total of 4,576 Ktoe, slightly lower the primary energy production of Spain. However, Eurostat reports for the same year a lower value of 3,953 Ktoe, close to what EurObserv'er presents, which in addition shows a higher value (5,127 Ktoe) for gross energy consumption.

Moreover, EurObserv'er shows also interesting data on energy from solid biomass consumed *per capita*. As showed in Table 49, Spain has a *per capita* consumption of 0.103 toe, while for Italy is lower, 0.087 toe, anyway, considerably lower than the European average of 0.170 toe *per capita*.

Table 49: *Per capita* bioenergy consumption

Per capita consumption (toe)	
Spain	0.103
Italy	0.087
EU average	0.170

Source: EurObserv'er

Finally, a comparison can be done for the pellets consumption. The data, according to the main informative sources on the sector, are presented in Table 50.

Table 50: Pellets market in Italy and Spain

Source	Production (t)		Consumption (t)		Import (t)		Export (t)	
	Spain	**Italy**	**Spain**	**Italy**	**Spain**	**Italy**	**Spain**	**Italy**
Eurostat, 2012	250,000	816,000			16,000	1,197,000	35,000	5,000
AEBIOM, 2013	250,000	300,000	200,000	2,513,000		1,090,054		
AVEBIOM, 2013	300,000		200,000				100,000	
AIEL, 2014				3,300,000				

From the data presented in the table it emerges clearly a difference between the two countries. Italy, as already mentioned, is the first market in Europe for pellet consumption (AIEL, 2011). According to the Spanish Biomass Association (AVEBIOM), the consumption by households and industrial pellet-burning boilers and stoves was around 200 thousand tons in 2013, compared to the 2,513 thousand tons reported by AEBIOM for Italy, and the 3,300 thousand tons estimated recently by AIEL. In Spain indeed, in front of a production of 300 thousand tons, 100 thousand tons are exported, as a demonstration of a very low domestic

demand. According to AVEBIOM, in 2013 in Spain 73,591 pellet-burning appliances stoves and boilers at household level were installed, compared to the 1.9 million estimated by AIEL in Italy.

7.1.5 Overview of the main results and final considerations

It is quite complex to compare the situations of the two countries on the basis of the data available both at national and European level; this is due to the very fragmented sources and use of different schemes to define biomass resources. Indeed, the comparison was possible only for few variables provided mainly at European level (*i.e.* FAOSTAT, Eurostat, AEBIOM, EurObserv'er), although these are not clear and completely reliable references to use in a comparative analysis. Further analyses are therefore needed to be able to assess the consistency of Spanish informative sources and data (as was done for Italy) and the methodologies behind the data provided by European agencies. An overall comparison of the main variables on the wood-energy market in Italy and Spain is presented in Table 51.

Table 51: Overall comparison between Italy and Spain

	Source	***year***	***Spain***	***Italy***
Bioenergy consumption per capita	***EurObserv'er***	2011	0.103 toe	0.087 toe
Gross final bioenergy consumption	***EurObserv'er***	2011	4,812 Ktoe	5,127 Ktoe
Primary bioenergy production	***Eurostat***	2011	4,925 Ktoe	3,953 Ktoe
Electricity from biomass	***NREAP***	2005	604 MW	1,990 MW
	NREAP (target)	2020	1,587 MW	4,650 MW
Heating from biomass	***NREAP***	2005	3,447 Ktoe	1,655 Ktoe
	NREAP (target)	2020	4,950 Ktoe	5,520 Ktoe
Fuelwood removals from forest	***MAGRAMA and ISTAT***	2011	3,900,000 m³	5,084,000 m³
Wood waste and residues production	***MAGRAMA and FAOSTAT***	2011	2,113,469 m³	904,000 m³
Pellets production	***Eurostat***	2011	250,000 t	816,000 t
Wood chips production	***FAOSTAT***	2012	1,541,425 m³	1,096,000 m³
Import of fuelwood	***FAOSTAT***	2011	5,000 m³	991,463 m³
Import of pellets	***FAOSTAT***	2012	16,316 t	1,197,000 t
Import of wood waste and residues	***FAOSTAT***	2011	74,119 m³	623,000 m³
Import of wood chips	***FAOSTAT***	2011	923,969 m³	844,000 m³
Pellets consumption	***AEBIOM***	2013	200,000 t	2,513,000 t

There are some considerations that can be drawn from this preliminary comparative analysis:

- also for Spain data collection on the wood-energy market is a problem. Indeed, on the bases of our review of the literature and statistical sources the information level on the wood-energy market in Spain results very low. MAGRAMA data were used to provide quite homogenized and complete statistical view on forest products, but the last data were published in 2011. Moreover, in Spain it is very difficult to find data on quantities of woody biomass used for energy production. Data are found in energy statistics, however energy units of measurements are difficult to be translated in biomass quantities units without having information on the efficiency of the transformation technology used, and on the moisture content and chemical composition of the woodfuels.
- In Italy and Spain bio- and wood-energy have different weights in their renewable energy strategies towards 2020, especially for what concern electricity generation, showing that the countries have different models of utilization and different structure in their supply chains.
- Fuelwood consumption at household level plays a much more important role in Italy; this is demonstrated by the data on fuelwood removals and import, and pellets consumption and import (see Table 50). However, these data are partially "invisible" in European and international statistics; this can be derived by a comparison of the figures on energy production and consumption (*i.e.* provided by EurObserv'er, Eurostat and even in the NREAPs) and the figures on woodfuels production and consumption.
- In Spain, opposite to Italy, the fuelwood removals from forest are very low compared to the timber for industry, resulting in a model that is more oriented to use wood wastes and residues for energy generation. This is an indicator that industries play an important role in Spain in wood-energy production and consumption. This can result in a potential positive factor in terms of sustainable cascade utilisation of wood resources deriving directly from the forests.

To conclude we can state that also this comparative analysis raises some doubts on the reliability of the statistical bases behind the data provided by the main European strategies and assumed in the NREAPs. Further and deeper investigation is therefore required before being able to draw accurate sectorial development programs. As an example, the use of econometric

modelling tools (*e.g.,* input-output tables) could be an interesting and effective approach to get insights on the market flows and the links among sectors but only an improved set of production and consumption data along the value chains can allow a correct analysis of the system and reliable comparative analysis.

8. Conclusions

In this thesis we have firstly reviewed the available literature and statistical sources concerning the woody biomass for energy market in Italy. A considerable amount of data and information are available on this topic. As highlighted also by previous studies, we have to face a problem of data consistency in the overall estimation of apparent consumption of bioenergy, due to the very fragmented sources of information, lack of coordination in terms of definitions and approaches in data collection. In order to assess the quality of the main informative sources we have done a consistency analysis involving a panel of experts representing different viewpoints in the wood-energy sector. In general, the results showed that the informative framework is, as expected, characterized by a high level of uncertainty and a low level of information and transparency in the available data. However, two considerations have been done:

- The estimations of the consumption levels reported by the most recent studies, like the survey made by AIEL based on the installed capacity of 27.30 million tons per year (AIEL, 2014), are recognized as reliable by the experts.
- The variables related to import and indirect supply of woody biomass are the most problematic to be assessed. Indeed these are the variable where less reliable information are available.

Through the consistency analysis we were also able to identify the main barriers toward a better quantification of the Italian wood-energy market. With regards to the different market flows these are the following ones.

- Concerning the production levels, it clearly emerged from our work that official data provided by ISTAT and other public authorities quantify only partially the woody biomass harvesting levels. The primarily reasons to explain this problem in the experts' opinion are related with the structural characteristics of the Italian wood-energy market itself, namely the non-regulated character, the large presence of micro and small enterprises operating on local and often informal value chains, and the relevant role of self-consumption. All these factors are considered to be critical barriers to data collection and market monitoring.
- Concerning the energy consumption, it has been showed that still exist an important lack of information on household consumption, i.e. the largest final consumer segment of woody biomass for energy sector.
- In the import flow, the presence of illegal and non-registered material import from neighbouring EU countries and the lack of an efficient monitoring and control system

are among the most stressed reasons behind the low data quality. Moreover, it is also been said to be complex to know the end use of the imported raw material (se the competitive wood uses).

- Finally, regarding the indirect supply flows, this also is considered to play a relevant role in biomass supply although its quantification has emerged to be a very complex operation due to the complexity of the value chain.

Secondly, in order to provide further elements for a better estimation of the consumption levels, we analyzed the ISTAT "Survey on consumption by families" focusing on the use and expenditure for fuelwood and charcoal at household level in Italy for the time series 1997-2012 (ISTAT, 2012). The main results drawn from the analysis were the following

- the percentage of households using fuelwood is 5.85% (in 2012), a data to be considerably lower than what other surveys carried out with a specific focus on wood-energy showed in the past, which was between 20 and 25%.
- The expenditure level resulting is nearly 2 billion Euros (in 2012), in line with what already proposed by some experts.
- Since the beginning of the years 2000s (2002-2003) there is an evident positive trend of increase in the percentage of households using fuelwood and the related expenditure.

With the information gathered we tried to calculate the quantity of fuelwood consumed at household level, obtaining a value of 10.50 million tons (in 2012), a much lower data than what other studies on household consumption showed, and also probably highlighting the still relevant role of self-consumption and "informal" fuelwood supply at household level.

In the third part, we carried out a two-round Delphi survey to tentatively estimate the production level of woody biomass in Italy based on experts' opinion, considering also import, indirect supply and energy consumption. The main conclusions from this part of the work were:

- We had to face a very high discordance and variability, especially in the preliminary estimation given by the experts, as a demonstration of deep uncertainty and lack of quantitative information on the market.
- In the review and revising process a reasonable level of agreement among the experts has been reached. The outcome was an estimation of the internal production of 12.91 Mt, an import flow of 5.91 Mt, an amount of woody biomass from the indirect supply of 3.78 Mt, and finally an energy consumption of 21.20 Mt.

- The internal production and the indirect supply were the variables with the lowest level of consensus reached by the experts.

Beside the specific estimates, the main consideration is that, based on the experts' opinion, the internal woody biomass harvesting for energy plays a much more important role then what is showed by official (and non-official) statistics, driven mainly by the high consumption level. However, it has been demonstrated extremely difficult at the moment to define a correct balance among the driving variables behind the apparent consumption where demand matches supply.

In addition, in order to assess the quality and availability of data in comparison with other countries, we conducted a comparative analysis between in Italy and Spain. Again, the comparative analysis resulted very complex to be carried out based on national and European level informative sources, showing that also for Spain data collection on the wood-energy market is a problem.

It can be concluded from our research work that the inconsistency of the wood-energy market informative framework in Italy is evident and demonstrable, and the current levels of information and data quality are not suitable for an accurate quantification and monitoring of the market. However, some new estimates and insights on the apparent consumption have been provided in this thesis and we recommend that further investigation should be conducted in order to understand how the domestic supply of woody biomass is structured and organized and which are the real levels of consumption. This is necessary in order to be able to assess the developments of a market that has been growing at fast rates in the last years. Moreover, the sustainability levels of domestic supply should also be defined and taken into account in national energy policy planning. Only with these two set of data and information we could define our strategy towards the renewable energy 2020 targets.

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INE: www.ine.es

ISTAT: www.istat.it

MAGRAMA: http://www.magrama.gob.es/es/

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Annex 1: Delphi questionnaire first round

Indagine su "Produzione e flussi di biomasse legnose a fini energetici in Italia"

Questionario esperti – 1° Round

Introduzione

Il presente questionario è organizzato in **due sezioni**, legate fra loro. Nella **prima sezione** si chiede di esprimere un **giudizio sull'affidabilità delle fonti**, distinguendo quelle sull'import, gli scarti derivanti dall'industra e il riciclo, i consumi energetici ed infine la produzione (o offerta) interna, seguendo lo schema dei flussi presentato a pagina 3. Nella **seconda sezione** si chiede invece di fornire una **stima**, sulla base delle sue conoscenze e del quadro informativo presentato nella sezione precedente, **della produzione interna** di biomasse legnose ai fini energetici in Italia, la quale rappresenta l'obiettivo centrale di questa indagine, ed in secondo luogo anche delle altre tre componenenti rappresentate nello schema dei flussi. Viene chiesto inoltre di esprimersi su tre domande integrative di carattere qualitativo su import e produzione interna.

Come anno orientativo di riferimento per la stima si assume il 2012 e come unità di misura le milioni di tonnellate l'anno (Mt/anno).

Una volta compilato, Le chiediamo di salvare il questionario con il nome **"Questionario_*Cognome*"** e inviarlo all'indirizzo email del mittente.

<u>Prima sezione</u>: Affidabilità delle fonti

Nota esplicativa: In questa prima sezione del questionario Le chiediamo di esprimere una valutazione in merito livello di affidabilità delle fonti (da 1 a 4, in cui: 1="*Per niente affidabile*"; 2="*Poco affidabile*"; 3="*Abbastanza affidabile*"; 4="*Molto affidabile*"), con la possibilità di inserire eventuali note o commenti alle scelte effettuate.

Le tabelle riportate presentano un inventario delle principali fonti informative esistenti sulla filiera delle biomasse legnose ai fini energetici, distinguendo fra import *(A)*, in sui abbiamo preso in considerazione i database internazionali e utlizzando il 2012 come anno di riferimento, gli scarti derivanti dall'industria e il reciclo *(B)*, i consumi energetici *(C)*, per i quali distinguiamo tra consumi civili ed industriali (centrali elettriche e a cogenerazione, teleriscaldamento e minireti), e consumi termici residenziali (distinguendo tra le diverse tipoligie di combustibili legnosi utilizzati), e infine la produzione (o offerta) interna *(D)*. Nelle tabelle tutti i dati sono espressi in milioni di tonnellate l'anno (Mt/anno), dove i dati fossero stati originariamente espressi in metri cubi, abbiamo utilizzato il coefficiente di conversione $1m^3$=0,5t di Mantau *et al.* (2010)[1].

Per quanto riguarda il quadro dei consumi energetici, presentiamo nella tabella corrispondente due nuovi lavori, il primo, condotto da AIEL (Assoiazione Italiana Energie Agroforestali), la quale ha proposto una nuova stima dei livelli di consumo di biomasse legnose calcolata a partire dal numero di impianti/apparecchi e capacità installata nel territorio nazionale (vedi AIEL, 2014), e il secondo lavoro, condotto dagli autori del presente questionario, che ha visto analizzati ed elaborati i risultati dell'indagine sui consumi delle famiglie condotta dall'Istat con riferimento alla spesa e consumo di legna da ardere a livello residenziale (vedi ns. elaborazione su dati Istat, 2012).

[1] Mantau, U. et al. (2010): EUwood - Real potential for changes in growth and use of EUforests. Final report. Hamburg/Germany, June 2010. 160 p.

A

Import (in Mt/anno)						
Fonti	Cippato (1)	Legna da ardere (e per carbone)	Residui legnosi (1)	Pellets	Totale	**Affidabilità della fonte** *(1=Per niente; 2=Poco; 3=Abbastanza; 4=Molto)*
FAOSTAT (2012)	0,42	0,50	0,31	1,20	2,43	1 ☐; 2☐; 3☐; 4☐; Non so ☐
Eurostat (2012)		0,50		1,20	-	1 ☐; 2☐; 3☐; 4☐; Non so ☐
UNCOMTRADE (2012)	0,43	0,72	1,91		3,06	1 ☐; 2☐; 3☐; 4☐; Non so ☐

(1) Da tenere conto della doppia finalità di questi prodotti (energia e produzioni industriali)

Eventuali note e commenti:

B

Produzioni derivanti dall'industria del legno e cartaria (in Mt/anno)					
Fonti	Scarti dalla lavorazione del legno	Scarti da industria della carta	Riciclo legno	Totale	**Affidabilità della fonte** *(1=Per niente; 2=Poco; 3=Abbastanza; 4=Molto)*
ITABIA (2008) (2)	4,20	0,30		-	1 ☐; 2☐; 3☐; 4☐; Non so ☐
ENAMA (2011) (3)	1,80	0,15	4,00	5,95	1 ☐; 2☐; 3☐; 4☐; Non so ☐
Rilegno (2012) (4)			0,08	-	1 ☐; 2☐; 3☐; 4☐; Non so ☐

(2) *Si riferisce in generale alla disponibilità di residui derivanti dall'industria*
(3) *Si riferisce solo agli scarti effettivamente utilizzabili a fini energetici, considerando però l'uso attuale che si divide tra energia e industria pannelli*
(4) *Si riferisce ai soli imballaggi legnosi che risultano effettivamente avviati a recupero energetico*

Eventuali note e commenti:

C

Consumi energetici di biomasse legnose (in Mt/anno)										
Fonti	Consumi civili ed industriali			Consumi termici residenziali					Totale	**Affidabilità della fonte** *(1=Per niente; 2=Poco; 3=Abbastanza; 4=Molto)*
	Centrali EE + CHP	Telerisc.	Minireti	Legna da ardere	Pellets, tronchetti	Cippato	Rifiuti e scarti	Tot. consumi domestici		
Istat (2010) (5)				3,78				-	-	1 ☐; 2☐; 3☐; 4☐; Non so ☐
Istituto Sociologia Rurale (1998) (6)				17,80				-	-	1 ☐; 2☐; 3☐; 4☐; Non so ☐
APAT (2003) (7)								21,50	-	1 ☐; 2☐; 3☐; 4☐; Non so ☐
ARPA (2007)				17,59	1,34		0,19	19,20	-	1 ☐; 2☐; 3☐; 4☐; Non so ☐
Marrazzi *et al.* (2006) (8)				22,60				-	-	1 ☐; 2☐; 3☐; 4☐; Non so ☐
AEBIOM (2008)					2,51			-	-	1 ☐; 2☐; 3☐; 4☐; Non so ☐
GSE (2009)	1,80 (no CHP)							-	-	1 ☐; 2☐; 3☐; 4☐; Non so ☐
Antonini e Francescato (2010)	1,80 (no CHP)	0,41	0,38	18,92	1,20	0,90	0,00	21,02	23,61	1 ☐; 2☐; 3☐; 4☐; Non so ☐
BEN (2012)								14,33	15,85	1 ☐; 2☐; 3☐; 4☐; Non so ☐
AIEL (2014) (9)	3,32 (incl. CHP)	0,413 (+ 1,34 caldaie >35kW)	0,0125	16,10	2,37	0,01		22,25	27,30	1 ☐; 2☐; 3☐; 4☐; Non so ☐
Istat (2012) (10)				10,50				-	-	1 ☐; 2☐; 3☐; 4☐; Non so ☐

(5) *Dalla serie storica delle utilizzazioni legnose ("legna come combustibile → legna da ardere e fasciname")*
(6) *Stima del consumo di legna da ardere delle famiglie rurali di collina e montagna*

(7) IL dato deriva da un'indagine finalizzata alla valutazione della capacità produttiva di biomasse legnose a fini energetici in Italia dell'ANPA del 2001
(8) Indagine condotta per conto della Fondazione Lombardia per l'Ambiente, dato estrapolato su scala nazionale dalla stima dei consumi di legna da ardere su un campione di 32500 nuclei famigliari lombardi
(9) Stima a partire dal numero di apparecchi e capacita installata in Italia.
(10) Nostra elaborazione a partire dai dati dell'Indagine sui consumi delle famiglie dell'Istat. Nell'indagine la voce di riferimento è "spesa per legna da ardere e carbone", ma la struttura del questionario ci fa pensare che vengano incluse anche altri tipi di combustibili legnosi (es. pellets e tronchetti).

Eventuali note e commenti:

D

Produzione interna (in Mt/anno)					
Fonti	Prelievi di legna da ardere	Produzioni			
		Produzione cippato	Produzione pellets	Residui	**Affidabilità della fonte** *(1=Per niente; 2=Poco; 3=Abbastanza; 4=Molto)*
Istat, 2011 *(11)*	2,54				1 ☐; 2☐; 3☐; 4☐; Non so ☐
FAOSTAT, 2012	2,69	0,54	0,30	0,45	1 ☐; 2☐; 3☐; 4☐; Non so ☐
Eurostat, 2013			0,82		1 ☐; 2☐; 3☐; 4☐; Non so ☐

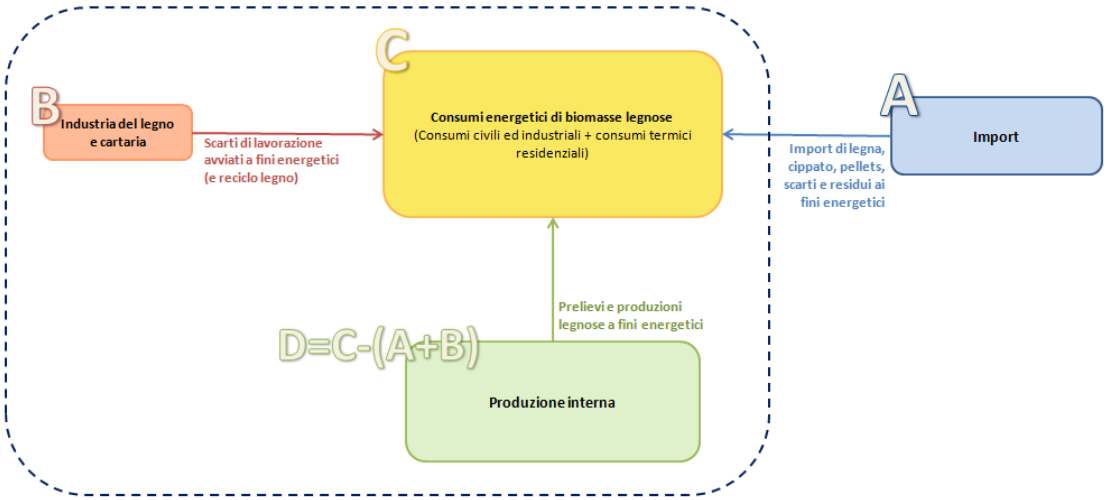
(11) Il dato è normalmente espresso in m³ (5,08 Mm³) corrispondenti al circa 70% dei prelievi totali

Eventuali note e commenti:

<u>Seconda sezione</u>: Stima del livello di produzione interna

Nota esplicativa: In questa seconda sezione Le chiediamo di fornire, sulla base delle sue conoscenze e del quadro informativo sopra presentato, una stima (anche in forma di *range*, nell'unità di misura delle Mt/anno) in primo luogo della produzione (o offerta) interna di biomasse legnose ai fini energetici, e in secondo luogo delle altre tre componenti dello schema dei flussi presentato, seguendo la logica per cui *D=C-(A+B)*.

Le chiediamo inoltre di integrare la propria stima con una breve motivazione ed esprimersi su tre domande di carattere qualitativo in merito a produzione interna e import.



(A) Import	Esprima qui la sua **stima** (in Mt/anno):	Spieghi qui la sua **motivazione**: **Domanda 1**. Quali crede siano i livelli di importazione di biomasse legnose non registrate nel mercato italiano? Molto alti ☐; Abbastanza alti ☐; Non molto alti ☐; Irrilevanti☐; Non so ☐
(B) Scarti dall'industria e riciclo	Esprima qui la sua **stima**	Spieghi qui la sua **motivazione**:
(C) Consumi energetici	Esprima qui la sua **stima**	Spieghi qui la sua **motivazione**:
(D) Produzione interna	Esprima qui la sua **stima**	Spieghi qui la sua **motivazione**: **Domanda 2**. Quanto crede sia rilevante il volume del commercio informale nella produzione di biomasse legnose ai fini energetici in Italia? Molto rilevante ☐; Abbastanza rilevante ☐; Poco rilevante ☐; Irrilevante ☐; Non so ☐ **Domanda 3**. Quanto crede sia importante la produzione ai fini dell'autoconsumo di legna da ardere nel settore domestico in Italia? Molto importante ☐; Abbastanza importante ☐; Non molto importante ☐; Irrilevante ☐; Non so ☐

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Annex 2: Delphi questionnaire round 2

Indagine su "Produzione e flussi di biomasse legnose a fini energetici in Italia"

Questionario esperti – 2° Round

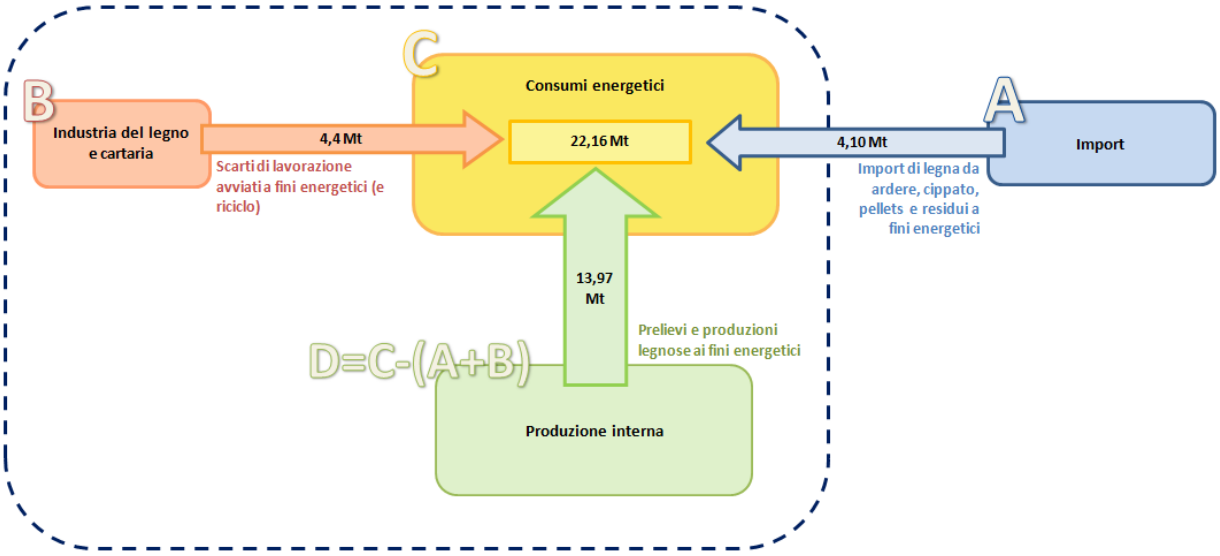
Il presente questionario è stato sviluppato dopo un'attenta analisi delle risposte ottenute nel primo "round" (10 questionari ricevuti). Il fine di questo secondo "round" è quello di far convengere il panel di esperti partecipanti all'indagine verso una visione comune, concentrandoci sul definire una stima dei livelli di produzione interna e flussi di mercato delle biomasse legnose ai fini energetici in Italia. Dopo aver analizzato le risposte e le opinioni ricevute, le abbiamo riassunte e rielaborate in quanto segue.

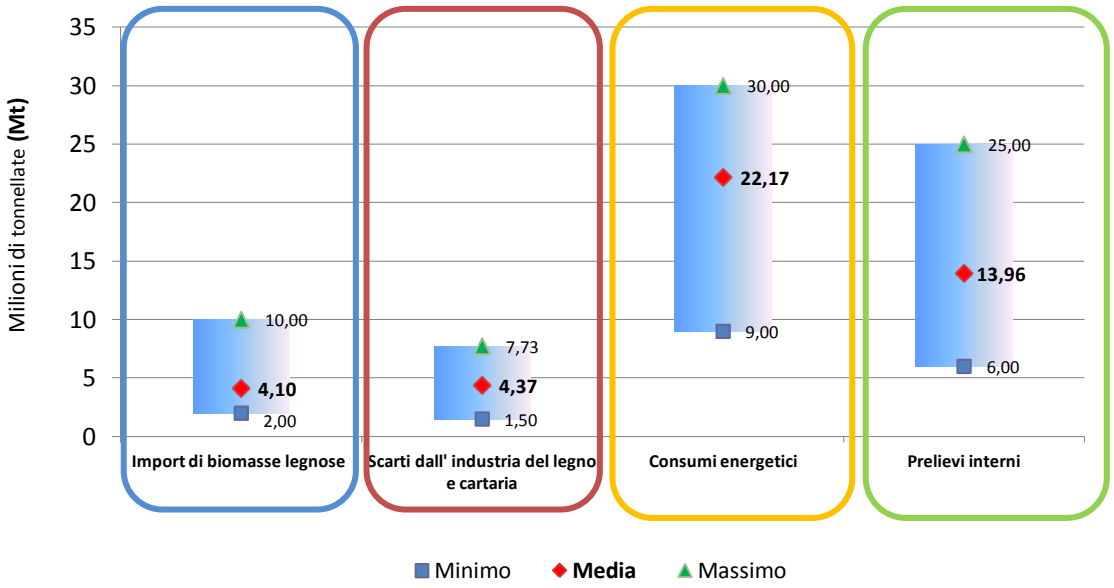
Le chiediamo inoltre, ai fini della pubblicazione dei risutati, se desidera che il suo nome venga citato o se invece preferisce mantenere l'anonimato.

Infine, anche questa volta Le chiediamo di salvare il questionario specificando il suo cognome ed inviarlo all'indirizzo del mittente.

Risultati primo "round"

***Nota esplicativa**: I risultati rielaborati del primo "round" dell'indagine sono riportati nello schema dei flussi e nel grafico seguenti. Nello schema dei flussi sono riportati i valori medi di stima emersi per i quattro flussi presi in considerazione, mentre nel grafico successivo i risultati sono espressi in un diagramma a scatola, mostrando per ognuno dei quattro flussi la media, i valori di massimo e minimo emerse la loro distribuzione.*





Da compilare

***Nota esplicativa**: Alla luce di quanto emerso, Le chiediamo di esprimersi nella tabella seguente nella quale Le viene chiesto se si trova concorde con queste stime (Si o No), e nel caso di disaccordo, di indicare una nuova stima, sulla base delle sue conoscenze e di quanto espresso dall'insieme di esperti, che ritiene rispecchi di più la realtà.*

Import	**Media** **4,10 Mt** *(risposte 7/10)*	Si ☐; No ☐	Nuova stima:
Scarti dall'industria e riciclo	**Media** **4,37 Mt** *(risposte 6/10)*	Si ☐; No ☐	Nuova stima:
Consumi energetici	**Media** **22,17 Mt** *(risposte 7/10)*	Si ☐; No ☐	Nuova stima:
Produzione interna	**Media** **13,96 Mt** *(risposte 9/10)*	Si ☐; No ☐	Nuova stima:

Eventuali note o commenti conclusivi:

Annex 3: Delphi questionnaire 1 – responses (first section)

a) import

Import (in Mt/year)															
Sources	*Chips*	*Firewood (and for charcoal)*	*Wood wastes and residues*	*Pellets*	*Total*	*Source reliability (Strongly reliable, sufficiently reliable, poorly reliable, not reliable I do not know)*									
						Hellrigl	**Romano**	**Tomassetti**	**Paniz**	**Mori**	**Zanuttini**	**Expert 1**	**Ciccarese**	**Gottero**	**Zimbalatti**
FAOSTAT (2012)	0,42	0,5	0,31	1,2	2,43	Poorly reliable	Poorly reliable	I do not know	Poorly reliable	Poorly reliable	I do not know	Poorly reliable	Not reliable	I do not know	Sufficiently reliable
Eurostat (2012)		0,5		1,2	-	Sufficiently reliable	Poorly reliable	I do not know	Poorly reliable	Poorly reliable	I do not know	Poorly reliable	Not reliable	I do not know	Poorly reliable
UNCOMTRADE (2012)	0,43	0,72	1,91		3,06	I do not know	Sufficiently reliable	I do not know	I do not know	I do not know	I do not know	Poorly reliable	Poorly reliable	I do not know	Poorly reliable
					Comments:	The ones on the import are often data of second or third elaboration, thus poorly reliable not because of the source itself, but because of the mechanism used to generate them	-	I do not have experience concerning import flows	-	-	-	All these data derives from the same official source (COMTRADE) based on official customs declarations. However, for what concerns specifically Italy, there is an evidence that these data are underestimated considering the high levels of woody biomass consumption estimated by several surveys (in Table C) that can not derive aoo from internal production/removals.	-	I think the origin of the data provided by these sources are more or less the same, with an exception for "wood wastes and residues" that probably in the UNCOMTRADE data comprehend also other categories. Concerning the others I think they are realistic, except for firewood.	-

b) Indirect supply from industry

By-products, wastes and residues from wood and pulp and paper industry (in Mt/year)														
Sources	Residues from wood-processing	Residues from pulp and paper industry	Post consumption wood	Total	Source reliability (Strongly reliable, sufficiently reliable, poorly reliable, not reliable I do not know)									
					Hellrigl	Romano	Tomassetti	Paniz	Mori	Zanuttini	Expert 1	Ciccarese	Zimbalatti	Gottero
ITABIA (2008) (2)	4,2	0,3		-	Poorly reliable	Poorly reliable	Sufficiently reliable	Poorly reliable	I do not know	I do not know	I do not know	Poorly reliable	Poorly reliable	Poorly reliable
ENAMA (2011) (3)	1,8	0,15	4	5,95	Poorly reliable	Sufficiently reliable	Sufficiently reliable	Sufficiently reliable	I do not know	I do not know	Sufficiently reliable	Sufficiently reliable	Poorly reliable	I do not know
Rilegno (2012) (4)			0,08	-	I do not know	Sufficiently reliable	Sufficiently reliable	I do not know	I do not know	I do not know	I do not know	Not reliable	Poorly reliable	Poorly reliable
Comments:					Production processes influence strongly on the amount of wastes and residues produced and available for energy purposes. In my opinion all these estimation are poorly realistic becasue it is a very complex issue.	-	There are other industrial sectors which consume large quantities of wood, for instance in the construction sector the small-medium enterprises use timber formworks builded with 2-2.5 mm beams, which then are retourned with cement and nails and thus utilizable only for fire, in the construction site or in workers' houses. There are then residues from agro-food industry such as olive, vineyards and other woody crops residues and also seeds and nutshells, produced both in small enterprises and on a large scale	-	-	-	It is very hard to express an opinion on these estimations withouth having information on the methodologies standing behind. This is valid also for the following tables, which shows a very uncertain data framework, with strong discrepancies. Thus, an opinion concerning the reliability has to be considered in terms of priorities among the sources more then an opinion on the specifi value showed.	-	-	The recent economic crisis sensibly influence the quantities of wood processed. The 2014 wood industry's situtation is hardly comparable with 2008.

c) Energy consumptions

Energy consumption (in Mt/year)																				
Sources	Industrial and commercial heat and power			Residential heating					Total	Source reliability (Strongly reliable, sufficiently reliable, poorly reliable, not reliable I do not know)									
	Power + CHP	District heating	Mini DH	Firewood	Pellets	Chips	Residues and wastes	Total residential		Hellrigl	Romano	Tomassetti	Paniz	Mori	Zanuttini	Expert 1	Ciccarese	Zimbalatti	Gottero
Istat (2010) (5)				3,78				-	-	Poorly reliable	Not reliable	Not reliable	Poorly reliable	Not reliable	Not reliable	Not reliable	Not reliable	Strongly reliable	Not reliable
Istituto Sociologia Rurale (1998) (6)				17,8				-	-	I do not know	Poorly reliable	Sufficientl y reliable	Sufficiently reliable	Poorly reliable	I do not know	I do not know	Sufficiently reliable	Poorly reliable	I do not know
APAT (2003) (7)								21,5	-	I do not know	Poorly reliable	I do not know	Sufficiently reliable	I do not know	I do not know	Poorly reliable	Sufficiently reliable	Poorly reliable	I do not know
ARPA (2007)				17,59	1,34		0,19	19,2	-	I do not know	Sufficient ly reliable	I do not know	Sufficiently reliable	I do not know	I do not know	Sufficiently reliable	Sufficiently reliable	Poorly reliable	Sufficiently reliable
Marrazzi *et al.* (2006) (8)				22,6				-	-	I do not know	Sufficient ly reliable	I do not know	Sufficiently reliable	I do not know	I do not know	Not reliable	Poorly reliable	Poorly reliable	Sufficiently reliable
AEBIOM (2008)					2,51			-	-	I do not know	Not reliable	I do not know	Sufficiently reliable	I do not know	I do not know	Sufficiently reliable	Sufficiently reliable	Sufficiently reliable	I do not know
GSE (2009)	1,80 (no CHP)							-	-	I do not know	Sufficient ly reliable	Strongly reliable	Sufficiently reliable	I do not know	Poorly reliable	I do not know	I do not know	Strongly reliable	Sufficiently reliable
Antonini e Francescato (2010)	1,80 (no CHP)	0,41	0,38	18,92	1,2	0,9	0	21,02	23,61	Sufficient ly reliable	Sufficient ly reliable	Strongly reliable	Sufficiently reliable	Sufficiently reliable	I do not know	Sufficiently reliable	Sufficiently reliable	Strongly reliable	Sufficiently reliable
BEN (2012)								14,33	15,85	I do not know	I do not know	Poorly reliable	Poorly reliable	I do not know	I do not know	Poorly reliable	I do not know	Sufficiently reliable	Not reliable
AIEL (2014) (9)	3,32 (incl. CHP)	0,413 (+ 1,34 caldaie >35kW)	0,0125	16,1	2,37	0,01		22,25	27,3	Sufficient ly reliable	Sufficient ly reliable	Strongly reliable	Sufficiently reliable	Sufficiently reliable	Strongly reliable	Sufficiently reliable	Sufficiently reliable	Strongly reliable	Sufficiently reliable
Istat (2012) (10)				10,5				-	-	Sufficient ly reliable	Sufficient ly reliable	Poorly reliable	Poorly reliable	Not reliable	Sufficiently reliable	I do not know	Not reliable	Strongly reliable	Poorly reliable

	The sources referred to the trade are the most reliable because it is always easier to analyze the seller standpoint that the consumers. The last two estimation seems to be good and give us an approximate value of 10-20 Mt/year.	-	The data from the census are reliable for what concern the applications installed, but not for what concern the expenditure because it is very difficult to coordinate and homogeneize all the sample (as an example remember the "exit poll" of the last political elections)	Most likely, woody biomass consumption for energy is around 20 Mt/year	From the data on the forest surfaces under authorization of cut in the last report on the state of Tuscany's forests, we can estimate a 1.1 Mt of fuelwood removals just from this region. Another study conducted in Piedmont by IPLA in 2005/2006 based on a survey that involved 3000 housholds, estimates a conusmption of 2.89 Mm^3, which corresponds according to the coefficient you use to around 1.44 Mt. Although these two studies are conducted in different years and with different methodologies, the sum just for these two regions is about 2.5 Mt, thus the official data provided by ISTAT is likely to be underestimated		The data reported from ISTAT (2010) - in the first raw - is not refered to consumption but on the production and this is not comparable with the others.			-

d) internal production

Internal removals and production (in Mt/year)															
Sources	Removals	Production			Source reliability (Strongly reliable, sufficiently reliable, poorly reliable, not reliable I do not know)										
		Chips	Pellets	Residues	Hellrigl	Romano	Tomassetti	Paniz	Mori	Zanuttini	Expert 1	Ciccarese	Zimbalatti	Gottero
Istat, 2011	2,54				Poorly reliable	Poorly reliable	Not reliable	Poorly reliable	Not reliable	Poorly reliable	Poorly reliable	Not reliable	Sufficiently reliable	Not reliable
FAOSTAT, 2012	2,69	0,54	0,3	0,45	Poorly reliable	Poorly reliable	Not reliable	Poorly reliable	Not reliable	I do not know	Poorly reliable	Not reliable	Poorly reliable	Not reliable
Eurostat, 2013			0,82		Poorly reliable	Poorly reliable	Sufficiently reliable	Poorly reliable	I do not know	I do not know	Poorly reliable	Not reliable	Poorly reliable	Not reliable
				Comments:	ISTAT data on wood removals are builded on different regional procedures.	-	In the surveys conducted by ENEA in the 90's, half of the consumers were saying to self-produce firewood		See previous comment in Table C	-	-			-

Annex4: Delphi questionnaire 1 – responses (second section)

a) import

Import	Estimation	Motivation
Hellrigl	I don't know	-
Romano	3,2	The value of import is clearly underestimated, as there are many cases of "illigal" import of not registered materials due to the lack of an efficient and coordinated monitoring and control system. Moreover, it is complex to know the final use of the imported raw material (i.e. chips). In these terms, I think it is realistic to increase by a 30 percent the official values. Based on the FAOSTAT data (the most complete) we would obtain 3.159 Mt
Tomassetti	3 to 5	-
Paniz	5 to 10	The high consumption levels estimated presume also high import levels
Mori	I do not know	-
Zanuttini	I do not know	We can think about a value doubled than the official one. The underestimation is mainly due to the imcompleteness of the basic information on which the final value is built. It is likely that import flows from neighbohoring EU countries are not registered due to the free-trade area inside the UE. Also a significant quota of not registered import from non-EU countries.
Expert 1	6	-
Ciccarese	2	The data on import presented by the agencies in Table A are likely to be underestimated as they don't register the quantities imported to fill biomass burning plants, higlighted also by some media.
Zimbalatti	3 to 4	-
Gottero	2 to 3	Compared with the official data, there might be an increase in pellets imports and other raw material for energy purposes not reistered, or registered under other categories (i.e. woody compost used as chips in large scale biomass plants)

b) Indirect supply from industry

Indirect supply from industry	Estimation	Motivation
Hellrigl	I do not know	The by-product, residues and wastes from the wood processing industry directed to energy production is about the 20% of the raw material input
Romano	7,73	This flow is the more difficult to quantify and the information available are not coherent and reliable. However, the current value is in my opinion underestimated of at least a 30 percent. Based on ENAMA estimation (the more complete) we would obtain 7.73 Mt/year.
Tomassetti	4 to 6	Including also agro-food residues and wastes
Paniz	1 to 2	The crisis that affects the wood industry since several years represents one of the major reasons of the reduction in residues and wastes available for energy production or for pellet production
Mori	I do not know	-
Zanuttini	I do not know	-
Expert 1	I do not know	I don't have enough experience on this issue to be able to provide an estimation
Ciccarese	4	As the ENAMA estimation
Zimbalatti	6 to 7	-
Gottero	1 to 2	Contruction due to the economic crisis affecting the wood industry in these years. If we would include the residues from urban-forestry this value can easily grow by three times

c) Energy consumptions

Energy consumption	Estimation	Motivation
HellrigI	10 to 20	-
Romano	30	Also in this case the data is evidently underestimated due to the lack of information on residential consumption levels. In this case, the data provided by AIEL seems the most reliable, although might be underestimated. The consumption level is almost certainly over the 30 Mt/year
Tomassetti	20 to 25	Considering the spreading of biomass-based application and the growing number of fuelwood selling enterprises, there is for sure a relevand growth in the market and a decreasing role of firewood self-consumption
Paniz	20	-
Mori	I do not know	-
Zanuttini	I do not know	-
Expert 1	I do not know	Information not quantificable based on the personal knowledge and experience. However, even considering the most reliable estimations, I think it is not possible at the moment to suppose a neutral balance (demand=supply). It is thus necessary to conduct more detailed surveys on the internal production of fuelwood, on the import and on the real energy produced
Ciccarese	21 to 27	-
Zimbalatti	8 to 10	-
Gottero	25 to 30	The large consumers are well monitored, but in some regions there is lack of data on small-scale application at household level that often consume more than the double of what official statistics registers

d) Internal production

Internal production	Estimation	Motivation
HellrigI	20 to 25	-
Romano	19,7	-
Tomassetti	10 to 15	-
Paniz	10 to 15	-
Mori	6 to 7	The wood-energy sector is largely unregulated, rich of irregular or improvvised operators that are involved in the fuelwood market in local chains, often not registering and bill their sell. Moreover, many forest operators are also "professional agricolturals enterprenours" , advantaged with lump sum payments
Zanuttini	I do not know	-
Expert 1	6	12 Mm^3 (about 6 Mt) should comprehend, beside the official quota, approximately the underestimation of wood removals fom forest in ISTAT data, more the primary "non-forest" producion and "non-commercial" production (woody crops, urbal forestry etc.) estimated to be about 1 Mt and directed mainly in the self-consumption chain
Ciccarese	15	-
Zimbalatti	7 to 8	-
Gottero	22 to 25	Self-consumption and the informal market plays an important role, at least in the north-western regions. According to some surveys that have been conducted on fuelwood consumption in Piedmont resutls the the consumption level is about the 400% more of the offial data (the same in Lombardy and Aosta Valley). Firewood is often the mojor component of forest enterprises businees, and moreover also farmers often cut the wood they need in their forests and even provide it to relatives and local families

Annex 5: Delphi questionnaire 2 – responses

		B. Hellrgl	R. Romano	P. Mori	L. Ciccarese	R. Zanuttini	G. Zimbalatti	Expert 1	G. Tomassetti	F. Gottero	A. Paniz
Import	Mean estimate **4,1 Mt**	I do not know	**7 Mt**	agree	agree	agree	-	**6 Mt**	agree	agree	Tra 6 e 10 Mt
Indirect supply	Mean estimate **4,37 Mt**	I do not know	agree	agree	agree	agree	-	agree	agree	**2 Mt**	2 Mt
Energy consumption	Mean estimate **22,17 Mt**	I do not know	agree	agree	agree	I do not know	-	**16,37 Mt**	I do not know	agree	agree
internal production	Mean estimate **13,96 Mt**	agree	agree	**12,5 Mt**	agree	agree	-	**6 MT**	agree	agree	agree

Comments:		In my opinion the import levels can be even higher than 7Mt	I suggest to lower the values of the internal production, especially the maximum from the range (25 Mt), because it would represent the 85 % of the annual increment and considering that there are many protected areas where utilizations are limited, this value is clearly too high. Assuming as an example the data on forest removals in Piedmont and Tuscany and prorate them at national level we obtain 12,5 Mt. Even though, we have to consider that there are some regions (ass Basilicata and Sardinia) with a large forest cover but with a very low utilization rate. Thus even 12,5 Mt is substantially an overestimation. However I leave this as a "new estimate" as I don't have other elements to quantify the utilization rate of these regions.		Concerning the consumption I'm not able to provide an evaluation		It is not an easy matter to quantify these elements. Even harder is to find a balance among the market fluxes (production=consumption-(import+indirect supply from industry). And surely is not possible to attributing to the internal production such a high value (probably obtained with an analytical substraction, giving the priority to the estimation of the consumption, which is reasonable). Thus, I stress the fact that the internal priduction can be at maximum 6 Mt (which would be the 100% more of the current ISTAT data)	Concerning the consumption this is the value of the esitmations made 15 years ago. Since then, the self-consumption is maybe the same, but it is evident that the fuelwood market is more organized and has grown, thus also the fuelwood consumption should have grown since then. There is then the issue of the calorific value, low for wood chips (2000 Cal/kg), medium for firewood (3000-3300) and high for pellets (4400), and this has to be taken into consideration in an energy balance. For instance hte 2,2-2,5 Mt of pellet import, have a double value compared to the chips.		

Annex 6: Calculations on the ISTAT “survey on consumption by families”

Primary residence data spreadsheet:

Primary residence													
Year	*Inflation rate*	*Total no. of Households*		*Electricity (€)*	*No. of Households*	*Gas from grid (€)*	*No. of Households*	*Gas in tanks (€)*	*No. of Households*	*kerosene, gasoline e other liquid fuels (€)*	*No. of Households*	*Fuelwood and charcoal (€)*	*No. of Households*
2012	**1,011**	25.383.756,64	Total monthly exp.	1174797175	25370658,68	1438596321	19238176,86	158263847,7	4294569,77	125920855,9	947089,64	158.369.668,18	1.486.922,69
			(in real values)	1187719944		1454420880		160004750		127305985,3		160.111.734,53	
			Average monthly exp.	46,28145438		56,67389352		6,234847345		4,960686381		6,24	
			(in real values)	46,79055038		57,29730635		6,303430666		5,015253931		6,31	
2011	**1,042**	25.165.001,80	Total monthly exp.	1088034363	25151495,69	1361546375	18922717,58	164176591	4368191,58	147268964,1	939098,35	143.653.303,53	1.403.386,63
			(in real values)	1133731806		1418731323		171072007,8		153454260,6		149.686.742,27	
			Average monthly exp.	43,23601371		54,10475969		6,52400474		5,852134058		5,71	
			(in real values)	45,05192629		56,3771596		6,798012939		6,097923689		5,95	
2010	**1,07**	24.898.005,64	Total monthly exp.	1116378692	24882901	1374484126	19127363,77	160762377	4106058,68	112189652,5	818372,25	151.321.012,09	1.456.776,28
			(in real values)	1194525201		1470698014		172015743,4		120042928,2		161.913.482,94	
			Average monthly exp.	44,83807693		55,20458729		6,45683752		4,50596944		6,08	
			(in real values)	47,97674231		59,0689084		6,908816146		4,821387301		6,50	
2009	**1,087**	24.609.430,50	Total monthly exp.	1146457967,62	24596912,79	1456430994,41	18682731,00	153522688,70	3891231,33	127379102,81	882064,45	128.107.127,35	1.166.272,60
			(in real values)	1246199811		1583140491		166879162,6		138461084,7		139.252.447,43	
			Average monthly exp.	46,59		59,18		6,24		5,18		5,21	
			(in real values)	50,6391162		64,33064312		6,781106235		5,626342501		5,66	
2008	**1,095**	24.257.661,15	Total monthly exp.	1110123592	24251045,01	1307695166	18132390,48	161333207	4287111,95	134085327,8	928882,57	131.274.005,22	1.260.907,99
			(in real values)	1215585333		1431926207		176659861,7		146823433,9		143.745.035,72	
			Average monthly exp.	45,76383458		53,90854288		6,650814602		5,527545583		5,41	
			(in real values)	50,11139886		59,02985445		7,282641989		6,052662414		5,93	
2007	**1,13**	23.881.224,06	Total monthly exp.	980387344,6	23874866	1120075988	17820478,29	142596234,6	4169276,81	118366900,1	910639,25	114.688.315,52	1.122.620,30
			(in real values)	1107837699		1265685867		161133745		133754597,1		129.597.796,53	
			Average monthly exp.	41,05264211		46,90195047		5,971060537		4,956483795		4,80	
			(in real values)	46,38948559		52,99920403		6,747298407		5,600826688		5,43	
2006	**1,15**	23.567.058,88	Total monthly exp.	943306907,3	23543715,13	1229522493	17132840,25	161879638,8	4494197,3	151508374,7	977758,95	110.190.264,42	1.112.537,42

			(in real values)	1084802943		1413950867		186161584,6		174234630,9		126.718.804,08		
			Average monthly exp.	40,02650106		52,17123187		6,868894402		6,428819798		4,68		
			(in real values)	46,03047622		59,99691666		7,899228562		7,393142768		5,38		
2005	**1,172**	23.267.709,58	Total monthly exp.	888216485,9	23261386,37	1121853909	16848602,88	163492237,7	4539650,19	146256963,1	975667,11	109.881.496,42	1.058.526,60	
			(in real values)	1040989721		1314812782		191612902,6		171413160,8		128.781.113,80		
			Average monthly exp.	38,17378255		48,21505552		7,026572047		6,285834135		4,72		
			(in real values)	44,73967315		56,50804507		8,235142439		7,366997607		5,53		
2004	**1,192**	22.813.191,90	Total monthly exp.	834587387,7	22790640,51	1051734048	16618662,19	150044071,7	4416452,11	139281483,8	939220,68	93.713.449,97	1.035.108,59	
			(in real values)	994828166,1		1253666985		178852533,5		166023528,7		111.706.432,36		
			Average monthly exp.	36,58354304		46,10201205		6,577074895		6,105304529		4,11		
			(in real values)	43,6075833		54,95359836		7,839873274		7,277522999		4,90		
2003	**1,216**	22.270.165,43	Total monthly exp.	814190818,3	22250527,47	970967972,6	15851331,62	146303167,1	4468487,17	123817324,2	913954,56	89.609.496,02	996.083,11	
			(in real values)	990056035,1		1180697055		177904651,2		150561866,3		108.965.147,16		
			Average monthly exp.	36,55971128		43,59949528		6,569469254		5,559784665		4,02		
			(in real values)	44,45660892		53,01698626		7,988474613		6,760698153		4,89		
2002	**1,246**	22.270.165,69	Total monthly exp.	761465772,5	22246948,3	942681977,7	15918736,82	131625247,6	4446348,55	135840136,9	1070199,33	84.801.697,51	1.023.324,18	
			(in real values)	948786352,5		1174581744		164005058,5		169256810,5		105.662.915,10		
			Average monthly exp.	34,19219161		42,32936525		5,910384745		6,099646439		3,81		
			(in real values)	42,60347075		52,74238911		7,364339392		7,600159464		4,74		
2001	**1,276**	22.191.989,27	Total monthly exp.	731494183,2	22167241,54	827319607,2	15494918,4	143637281,3	5040568,18	155654356,7	1081481,24	94.712.743,06	1.220.504,99	
			(in real values)	933386577,8		1055659819		183281170,9		198614959,2		120.853.460,14		
			Average monthly exp.	32,96208259		37,28010126		6,472483359		7,013988464		4,27		
			(in real values)	42,05961739		47,56940921		8,258888766		8,94984928		5,45		
2000	**1,311**	21.967.027,66	Total monthly exp.	683353730,9	21932798	837704314,1	15051025,65	141678899,3	5384183,54	164606618,8	1221316,18	91.327.403,83	1.222.355,94	
			(in real values)	895876741,2		1098230356		185741037		215799277,2		119.730.226,42		
			Average monthly exp.	31,10815635		38,13462281		6,449616283		7,493349638		4,16		
			(in real values)	40,78279297		49,9944905		8,455446947		9,823781376		5,45		
1999	**1,344**	21.770.664,41	Total monthly exp.	683122547,5	21748073,2	757701321,2	13945697,52	146098087,6	6042624,78	192326182,6	1371331,08	97.734.591,17	1.313.081,98	
			(in real values)	918116703,9		1018350576		196355829,7		258486389,4		131.355.290,53		
			Average monthly exp.	31,37812125		34,80377571		6,710777624		8,83418985		4,49		
			(in real values)	42,17219496		46,77627455		9,019285126		11,87315116		6,03		
1998	**1,365**	21.643.985,02	Total monthly exp.	674489263,2	21621777,05	747879823,7	14400115,62	134215065,4	5491428,64	167996517,2	1228322,46	83.561.556,37	1.132.436,65	

			(in real values)	920677844,2		1020855959		183203564,3		229315245,9		114.061.524,44	
			Average monthly exp.	31,16289641		34,5537027		6,201033004		7,761810822		3,86	
			(in real values)	42,53735361		47,16580419		8,464410051		10,59487177		5,27	
1997	**1,39**	21.458.828,44	Total monthly exp.	654752755,7	21430763,07	699383164,8	14006863,93	127653518,9	5763783,22	172709799,9	1339449,92	86.007.926,56	1.271.849,46
			(in real values)	910106330,4		972142599,1		177438391,2		240066621,9		119.551.017,92	
			Average monthly exp.	30,51204578		32,59186152		5,948764595		8,048426336		4,01	
			(in real values)	42,41174363		45,30268751		8,268782787		11,18731261		5,57	

Second house data spreadsheet:

Year	Inflation rate	Total no.N of households	No. of second house holders		Electricity *(€)*	*No. of Households*	Gas from grid *(€)*	*No. of Households*	Gas in tanks *(€)*	*No. of Households*	kerosene, gasoline e other liquid fuels *(€)*	*No. of Households*	Fuelwood and charcoal *(€)*	*No. of Households*
2012	**1,011**	25.383.756,64	/	Total monthly exp.	39051925	1728255	23868115	699238,6	7003231	399003,1	3692234	48310,64	1957653,811	55954,3
				(in real values)	39481496		24130664		7080267		3732848		1979188,003	
				Average monthly exp.	1,5384612		0,940291		0,275894		0,145457		0,077122305	
				(in real values)	1,5553843		0,950634		0,278929		0,147057		0,07797065	
2011	**1,042**	25.165.001,80	2314331,96	Total monthly exp.	39181658	1652855	22329508	643159,5	6483320	372378,9	2648533	47234,86	1646969,916	41495,08
				(in real values)	40827288		23267347		6755619		2759771		1716142,653	
				Average monthly exp.	1,5569901		0,887324		0,257632		0,105247		0,065446843	
				(in real values)	1,6223837		0,924592		0,268453		0,109667		0,06819561	
2010	**1,07**	24.898.005,64	2393471,56	Total monthly exp.	39641322	1622218	21596630	627820,3	6648603	369753,9	3587626	45593,7	2395042,986	55646,09
				(in real values)	42416214		23108394		7114005		3838760		2562695,995	
				Average monthly exp.	1,5921485		0,867404		0,267034		0,144093		0,09619417	
				(in real values)	1,7035989		0,928122		0,285726		0,154179		0,102927762	
2009	**1,087**	24.609.430,50	2292875,68	Total monthly exp.	41996933	1562276	20575044	588061,1	5090021	288931,1	2128466	26551,49	769961,7147	18654,96
				(in real values)	45650666		22365073		5532853		2313642		836948,3839	
				Average monthly exp.	1,7065382		0,836063		0,206832		0,08649		0,031287263	
				(in real values)	1,855007		0,908801		0,224827		0,094014		0,034009254	
2008	**1,095**	24.257.661,15	2010998,33	Total monthly exp.	43391859	1488264	18672162	541227,9	6084922	342740,1	2459364	30244,53	1851044,485	29455,24
				(in real values)	47514086		20446018		6662990		2693004		2026893,711	
				Average monthly exp.	1,7887899		0,769743		0,250845		0,101385		0,076307624	
				(in real values)	1,9587249		0,842868		0,274676		0,111017		0,083556848	
2007	**1,13**	23.881.224,06	1874226,48	Total monthly exp.	32069352	1328352	16809191	529247,3	5655761	299759,1	1495305	38618,87	1700417,784	34937,7
				(in real values)	36238368		18994386		6391010		1689695		1921472,096	
				Average monthly exp.	1,3428689		0,703866		0,236829		0,062614		0,071203125	
				(in real values)	1,5174418		0,795369		0,267617		0,070754		0,080459531	
2006	**1,15**	23.567.058,88	3339359,11	Total monthly exp.	35622017	1408722	16538954	527145,9	5208710	284071	3056128	40015,72	1580834,788	27622,11
				(in real values)	40965319		19019797		5990016		3514547		1817960,006	
				Average monthly exp.	1,5115173		0,701783		0,221017		0,129678		0,067078153	

				(in real values)	1,7382449		0,80705		0,254169		0,14913		0,077139876		
2005	**1,172**	23.267.709,58	1866064,21	Total monthly exp.	30553099	1373225	14068197	462212,5	5475012	318151	2230332	22764,9	1187346,481	32327,85	
				(in real values)	35808232		16487927		6416714		2613949		1391570,076		
				Average monthly exp.	1,3131116		0,604623		0,235305		0,095855		0,051029796		
				(in real values)	1,5389668		0,708618		0,275778		0,112342		0,059806921		
2004	**1,192**	22.813.191,90	2021207,33	Total monthly exp.	30933139	1471359	13850820	491840,8	5516644	340614,5	1412379	31744,92	1701470,759	37001,93	
				(in real values)	36872301		16510177		6575840		1683556		2028153,145		
				Average monthly exp.	1,3559321		0,607141		0,241818		0,061911		0,074582757		
				(in real values)	1,616271		0,723712		0,288247		0,073797		0,088902647		
2003	**1,216**	22.270.165,43	2139885,19	Total monthly exp.	30461976	1536340	12280460	464023,5	4702020	369436,9	2517061	40697,18	1161895,492	44054,9	
				(in real values)	37041762		14933040		5717656		3060747		1412864,918		
				Average monthly exp.	1,3678379		0,551431		0,211135		0,113024		0,052172737		
				(in real values)	1,6632909		0,67054		0,256741		0,137437		0,063442049		
2002	**1,246**	22.270.165,69	1736629,71	Total monthly exp.	27335764	1421277	12489033	467889	4572372	339943,4	2538943	66311,2	1280155,917	42938,29	
				(in real values)	34060362		15561335		5697176		3163523		1595074,272		
				Average monthly exp.	1,2274612		0,560797		0,205314		0,114006		0,057482999		
				(in real values)	1,5294167		0,698753		0,255821		0,142052		0,071623817		
2001	**1,276**	22.191.989,27	1824278,85	Total monthly exp.	25301953	1423601	10972407	447426,6	4333493	396325,8	3641603	57956,56	1468626,047	39145,56	
				(in real values)	32285292		14000791		5529537		4646685		1873966,836		
				Average monthly exp.	2207,617		957,3519		378,1009		317,733		0,066178206		
				(in real values)	2816,9193		1221,581		482,4568		405,4273		0,084443391		
2000	**1,311**	21.967.027,66	1933700,86	Total monthly exp.	28148674	1594707	8961369	419373,5	4399249	450446,1	4492883	67075,56	1656540,028	52149,91	
				(in real values)	36902912		11748355		5767416		5890170		2171723,976		
				Average monthly exp.	1,1985701		0,61198		0,199498		0,147137		0,061513727		
				(in real values)	1,5713254		0,802306		0,261542		0,192896		0,080644496		
1999	**1,344**	21.770.664,41	1933700,86	Total monthly exp.	28148674	1594707	8961369	419373,5	4399249	450446,1	4492883	67075,56	1656540,028	52149,91	
				(in real values)	37831818		12044080		5912591		6038435		2226389,797		
				Average monthly exp.	1,2929635		0,411626		0,202072		0,206373		0,076090467		
				(in real values)	1,7377429		0,553225		0,271585		0,277366		0,102265588		
1998	**1,365**	21.643.985,02	2028704,32	Total monthly exp.	28748938	1657478	8592614	433824	5293093	520796	3256927	67751,27	1500377,103	54468,65	
				(in real values)	39242300		11728918		7225072		4445706		2048014,745		
				Average monthly exp.	1,3282645		0,396998		0,244553		0,150477		0,069320742		

				(in real values)	1,8130811		0,541902		0,333814		0,205401		0,094622813		
1997	**1,39**	21.458.828,44	1834955,49	Total monthly exp.	27925782	1548614	8012405	411386,8	6463865	468033,5	3094624	71023,51	1470924,663	55308,07	
				(in real values)	38816837		11137243		8984772		4301527		2044585,281		
				Average monthly exp.	1,3013656		0,373385		0,301222		0,144212		0,068546364		
				(in real values)	1,8088982		0,519005		0,418698		0,200455		0,095279446		

Other elaborations:

Year	Total Italian household	Households registering an expenditure for fuelwood and charcoal (primary residence)	% primary residence
1997	21.458.828	1.271.849	5,93
1998	21.643.985	1.132.437	5,23
1999	21.770.664	1.313.082	6,03
2000	21.967.028	1.222.356	5,56
2001	22.191.989	1.220.505	5,50
2002	22.270.166	1.023.324	4,60
2003	22.270.165	996.083	4,47
2004	22.813.192	1.035.109	4,54
2005	23.267.710	1.058.527	4,55
2006	23.567.059	1.112.537	4,72
2007	23.881.224	1.122.620	4,70
2008	24.257.661	1.260.908	5,20
2009	24.609.430	1.166.273	4,74
2010	24.898.006	1.456.776	5,85
2011	25.165.002	1.403.387	5,58
2012	25.383.757	1.486.923	5,86

Year	Total Italian household	Second house holders	Housholds registering an expenditure for fuelwood and charcoal (second house)	% for the second houses	% on the second house holders
1997	21.458.828	1.834.955	55.308	0,26	3,01
1998	21.643.985	2.028.704	54.469	0,25	2,68
1999	21.770.664	1.933.701	52.150	0,24	2,70
2000	21.967.028	1.933.701	52.150	0,24	2,70
2001	22.191.989	1.824.279	39.146	0,18	2,15
2002	22.270.166	1.736.630	42.938	0,19	2,47
2003	22.270.165	2.139.885	44.055	0,20	2,06
2004	22.813.192	2.021.207	37.002	0,16	1,83
2005	23.267.710	1.866.064	32.328	0,14	1,73
2006	23.567.059	3.339.359	27.622	0,12	0,83
2007	23.881.224	1.874.226	34.938	0,15	1,86
2008	24.257.661	2.010.998	29.455	0,12	1,46
2009	24.609.430	2.292.876	18.655	0,08	0,81
2010	24.898.006	2.393.472	55.646	0,22	2,32
2011	25.165.002	2.314.332	41.495	0,16	1,79
2012	25.383.757	2.438.987	55.954	0,22	2,29

Average montly expenditure (second house)					
Year	Electricity	Gas from grid	Gas in tanks	kerosene, gasoline e other liquid fuels	Fuelwood and charcoal
1997	1,808898	0,519005	0,418698	0,200454898	0,095279446
1998	1,813081	0,541902	0,333814	0,205401435	0,094622813
1999	1,737743	0,553225	0,271585	0,27736568	0,102265588
2000	1,571325	0,802306	0,261542	0,192896026	0,080644496
2001	1,140139	0,494431	0,195273	0,164095382	0,066178206
2002	1,529417	0,698753	0,255821	0,142052049	0,071623817
2003	1,663291	0,67054	0,256741	0,137437088	0,063442049
2004	1,616271	0,723712	0,288247	0,073797475	0,088902647
2005	1,538967	0,708618	0,275778	0,11234235	0,059806921
2006	1,738245	0,80705	0,254169	0,149129659	0,077139876
2007	1,517442	0,795369	0,267617	0,0707541	0,080459531
2008	1,958725	0,842868	0,274676	0,111016635	0,083556848
2009	1,855007	0,908801	0,224827	0,094014448	0,034009254
2010	1,703599	0,928122	0,285726	0,154179418	0,102927762
2011	1,622384	0,924592	0,268453	0,10966704	0,06819561
2012	1,555384	0,950634	0,278929	0,147056581	0,07797065

Average montly expenditure (primary residence)					
Year	Electricity	Gas from grid	Gas in tanks	Kerosene, gasoline and other liquid fuels	Fuelwood and charcoal
1997	42,41174	45,30269	8,268783	11,18731261	5,571181
1998	42,53735	47,1658	8,46441	10,59487177	5,269895
1999	42,17219	46,77627	9,019285	11,87315116	6,033591
2000	40,78279	49,99449	8,455447	9,823781376	5,450452
2001	42,05962	47,56941	8,258889	8,94984928	5,445815
2002	42,60347	52,74239	7,364339	7,600159464	4,744595
2003	44,45661	53,01699	7,988475	6,760698153	4,892876
2004	43,60758	54,9536	7,839873	7,277522999	4,896572
2005	44,73967	56,50805	8,235142	7,366997607	5,534757
2006	46,03048	59,99692	7,899229	7,393142768	5,376946
2007	46,38949	52,9992	6,747298	5,600826688	5,426765
2008	50,1114	59,02985	7,282642	6,052662414	5,925758
2009	50,63912	64,33064	6,781106	5,626342501	5,658499
2010	47,97674	59,06891	6,908816	4,821387301	6,50307
2011	45,05193	56,37716	6,798013	6,097923689	5,948211
2012	46,79055	57,29731	6,303431	5,015253931	6,307645

Average montly expenditure (total)					
Year	Electricity	Gas from grid	Gas in tanks	Kerosene, gasoline and other liquid fuels	Fuelwood and charcoal
1997	44,22	45,82	8,69	11,39	5,67
1998	44,35	47,71	8,80	10,80	5,36
1999	43,91	47,33	9,29	12,15	6,14
2000	42,35	50,80	8,72	10,02	5,53
2001	43,20	48,06	8,45	9,11	5,51
2002	44,13	53,44	7,62	7,74	4,82
2003	46,12	53,69	8,25	6,90	4,96
2004	45,22	55,68	8,13	7,35	4,99
2005	46,28	57,22	8,51	7,48	5,59
2006	47,77	60,80	8,15	7,54	5,45
2007	47,91	53,79	7,01	5,67	5,51
2008	52,07	59,87	7,56	6,16	6,01
2009	52,49	65,24	7,01	5,72	5,69
2010	49,68	60,00	7,19	4,98	6,61
2011	46,67	57,30	7,07	6,21	6,02
2012	48,35	58,25	6,58	5,16	6,39

% variation					
Year	Power energy	Gas from grid	Gas tanks	Kerosene, gasoline and other liquid fuels	Fuelwood and charcoal
1997	0	0	0	0	0
1998	0,29	4,12	1,27	-5,16	-5,33
1999	-0,70	3,29	6,95	6,70	8,28
2000	-4,22	10,86	0,34	-12,04	-2,39
2001	-2,31	4,89	-2,69	-19,97	-2,73
2002	-0,20	16,63	-12,29	-32,01	-15,00
2003	4,29	17,17	-5,09	-39,43	-12,53
2004	2,27	21,51	-6,44	-35,45	-12,02
2005	4,65	24,87	-2,03	-34,32	-1,27
2006	8,02	32,70	-6,15	-33,77	-3,75
2007	8,34	17,40	-19,25	-50,20	-2,81
2008	17,75	30,66	-13,01	-45,87	6,05
2009	18,71	42,38	-19,36	-49,77	0,46
2010	12,35	30,94	-17,18	-56,31	16,58
2011	5,55	25,05	-18,66	-45,49	6,18
2012	9,33	27,12	-24,23	-54,67	12,69

Elaborations:

Year	Total exp. Primary residence (montly)	Total exp. Second house (montly)	Total ex. (montly)	Total exp. Primary residence (year)	Total exp. Second house (year)	Total ex. (year)	CPI	CPI + VAT	Consumption
1997	119.551.017,92	2.044.585,28	121.595.603,20	1.434.612.215,02	24.535.023,37	1.459.147.238,39	143,10	171,72	8.497.425,30
1998	114.061.524,44	2.048.014,75	116.109.539,18	1.368.738.293,28	24.576.176,94	1.393.314.470,22	143,10	171,72	8.114.044,51
1999	131.355.290,53	2.226.389,80	133.581.680,33	1.576.263.486,36	26.716.677,57	1.602.980.163,93	141,63	169,96	9.431.447,58
2000	119.730.226,42	2.171.723,98	121.901.950,40	1.436.762.717,05	26.060.687,72	1.462.823.404,77	141,63	169,96	8.606.807,85
2001	120.853.460,14	1.873.966,84	122.727.426,98	1.450.241.521,72	22.487.602,04	1.472.729.123,76	141,63	169,96	8.665.090,08
2002	105.662.915,10	1.595.074,27	107.257.989,37	1.267.954.981,15	19.140.891,27	1.287.095.872,41	142,00	170,40	7.553.379,53
2003	108.965.147,16	1.412.864,92	110.378.012,08	1.307.581.765,96	16.954.379,01	1.324.536.144,97	142,00	170,40	7.773.099,44
2004	111.706.432,36	2.028.153,14	113.734.585,51	1.340.477.188,33	24.337.837,74	1.364.815.026,07	138,38	166,05	8.219.301,57
2005	128.781.113,80	1.391.570,08	130.172.683,88	1.545.373.365,60	16.698.840,91	1.562.072.206,51	141,88	170,25	9.175.167,15
2006	126.718.804,08	1.817.960,01	128.536.764,08	1.520.625.648,94	21.815.520,07	1.542.441.169,02	146,25	175,50	8.788.838,57
2007	129.597.796,53	1.921.472,10	131.519.268,63	1.555.173.558,39	23.057.665,15	1.578.231.223,54	144,38	173,25	9.109.559,73
2008	143.745.035,72	2.026.893,71	145.771.929,43	1.724.940.428,63	24.322.724,53	1.749.263.153,16	147,25	176,70	9.899.621,69
2009	139.252.447,43	836.948,38	140.089.395,82	1.671.029.369,21	10.043.380,61	1.681.072.749,82	153,00	183,60	9.156.169,66
2010	161.913.482,94	2.562.696,00	164.476.178,93	1.942.961.795,27	30.752.351,94	1.973.714.147,21	149,38	179,25	11.010.957,59
2011	149.686.742,27	1.716.142,65	151.402.884,93	1.796.240.907,29	20.593.711,83	1.816.834.619,12	150,25	180,30	10.076.731,11
2012	160.111.734,53	1.979.188,00	162.090.922,53	1.921.340.814,33	23.750.256,03	1.945.091.070,36	154,50	185,40	10.491.321,85