

Empirical research on wood use for energy: experience in Italy

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Focus on wood
use in household

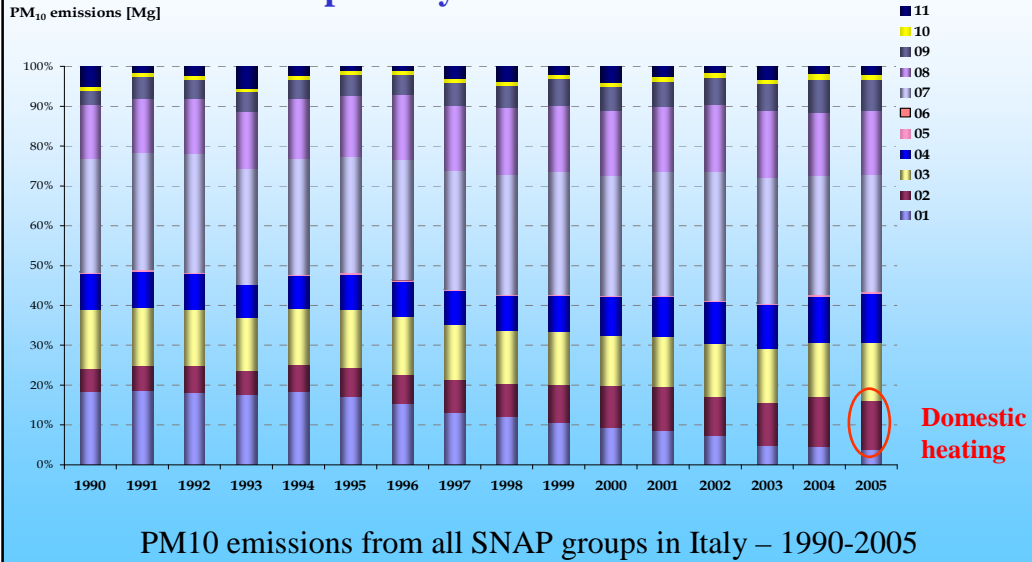
Outline:

- Introduction
- Methodology
- Results
- Conclusions

Pescocostanzo
(Abruzzo region,
August 2006)

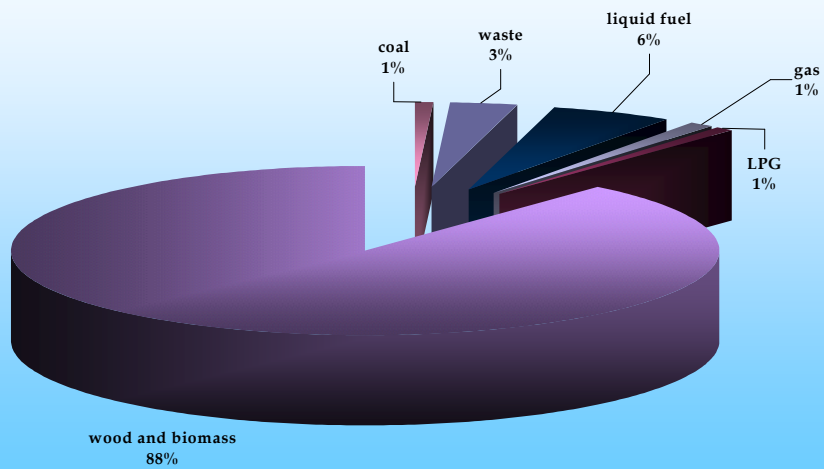


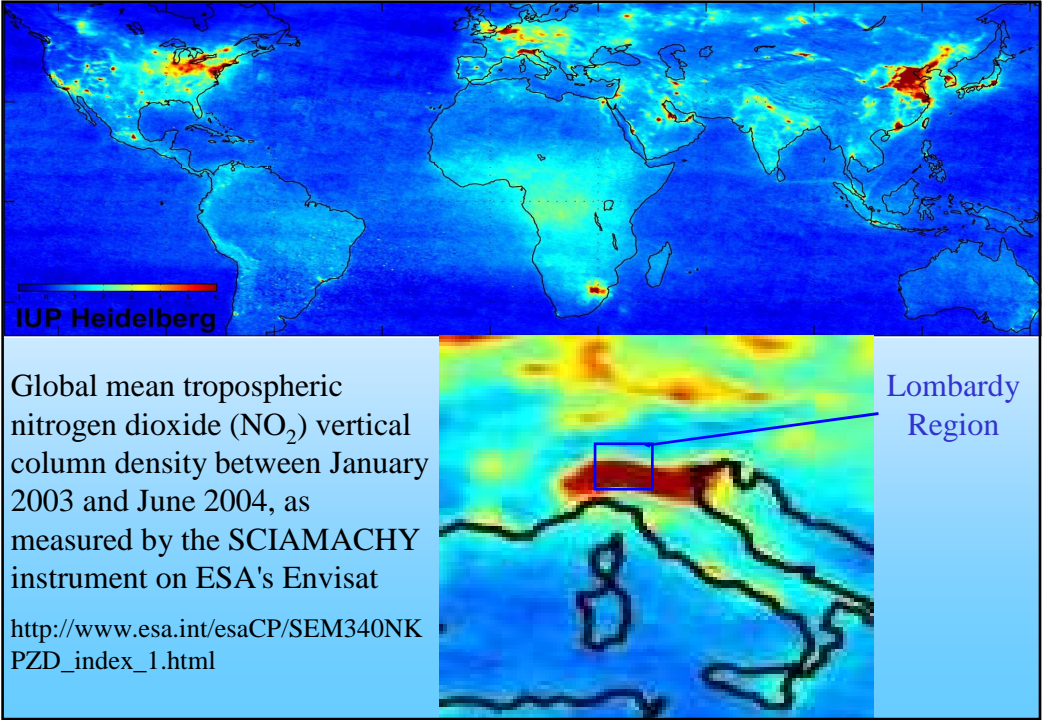
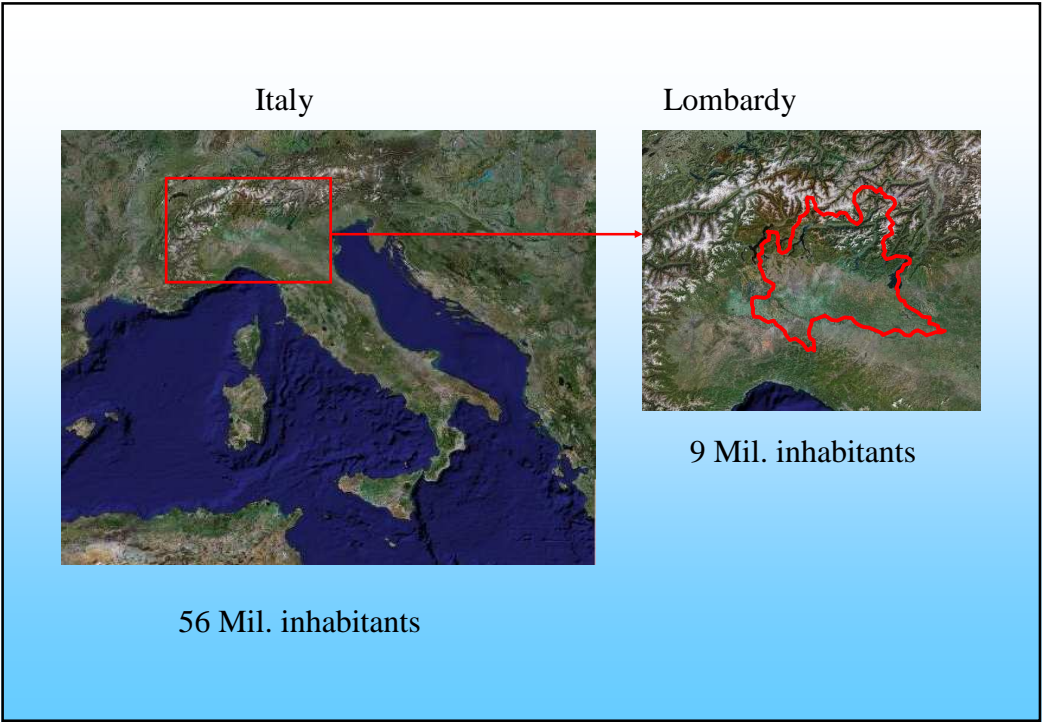
Wood combustion has been identified in the Italian and Lombardy emission inventory as an important source of primary PM10 emissions



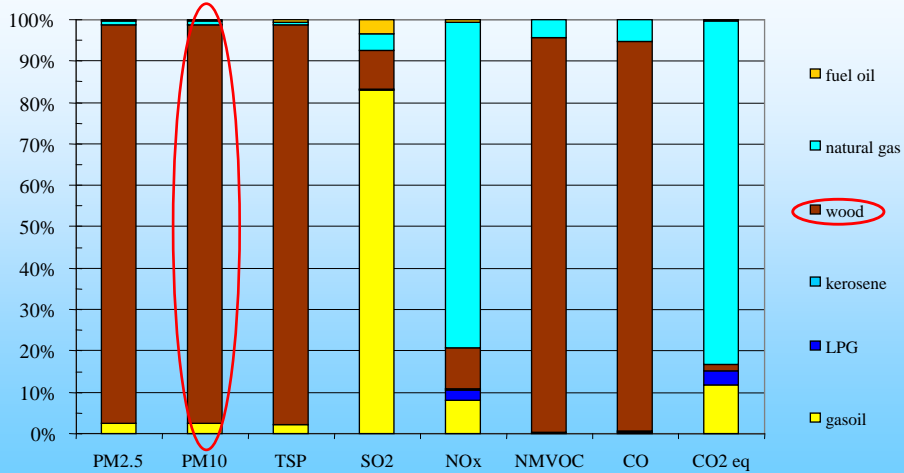
PM₁₀ emissions from domestic heating, by fuel

PM₁₀ Em ission - Domesting Heating [Mg]

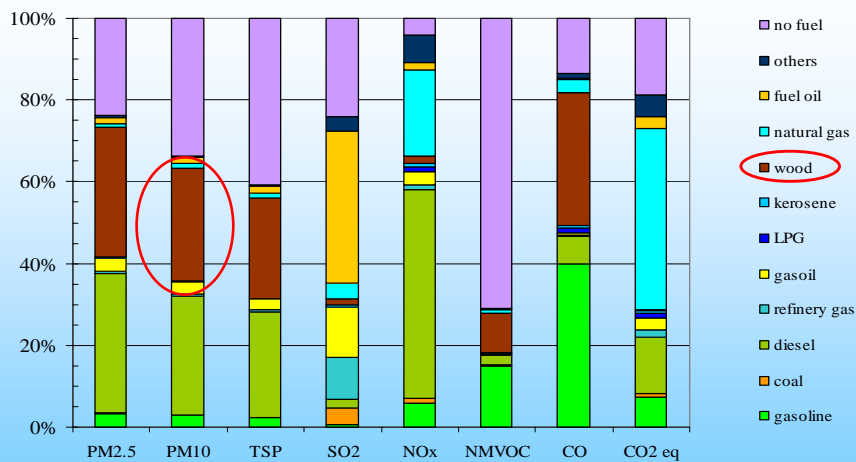




Lombardy 205 emissions from domestic heating, by fuel



Lombardy 2005 emissions by fuel



In Lombardy, wood combustion in appliances with less than 65% of thermal efficiency has been prohibited since winter 2006/2007, in every municipality in the plain (altitude < 300 meters)

Different works have been done to further investigate the role of wood consumption on air quality, in particular:

- Patterns of wood consumption
- Emission factors
- Presence of wood tracers in air samples

Patterns of wood consumption

A number of works highlighted the relevant use of wood for residential heating in Italy and in Lombardy

- At the national level (ENEA, Italian Agency for Energy, New technologies and environment): surveys in 1997 and in 1999
- At the Lombardy Region level (Lombardy Foundation for the Environment*): survey among 30.000 middle school students in 2004
- At the national and Lombardy level (APAT-ARPA**) survey in 2006
- Milan Province level (ARPA-CRA): survey among 10.000 families (2007)
- At the Lombardy level (JRC ISPRA): in 2008

* Caserini S. et al. (2005) "Extensive survey on wood use for domestic heating in Lombardy: implication for PM emission inventory", 14th US-EPA International Emission Inventory Conference, Las Vegas, Nevada, April 11-14, 2005

** Caserini S. et al. (2007) "New insight into the role of wood combustion as key PM source in Italy and in Lombardy region", 16th US-EPA International Emission Inventory Conference, Raleigh, North Carolina, May 14 - 17, 2007

ARPA - APAT 2006 survey on wood use

ARPA-APAT 2006 survey combine two methods:

- CATI (Computer Assisted Telephone Interviewing)
- Telepanel (representative panel of the Italian population connected to the data center via PC)

→ 5,000 families

Sample processed and expanded to the reference universe (21 million families) by usual statistical inference techniques

- 40 questions in every interview

Interviews made by C.R.A. (Customized Research & Analysis), a private company of the statistical survey sector

Sample grouped
by four layers:

8 macro-regions



Other layers

3 **altitude** layers:

Plain (up to 300 m)

Hill (from 300 to 600 m)

Mountain (over 600 m)

5 **number of members** layers:

one member

2 members

3 members

4 members

5 members and more

5 **size of settlements** layers :

up to 5,000 inhabitants

from 5,001 to 20,000

from 20,001 to 50,000


from 50,001 to 100,000

more than 100,000 inhabitants

Diffusion of wood use


≅ **26%** of Italian families use wood for domestic uses

85% in the residence house

 10% in the holiday home

5% in both of them

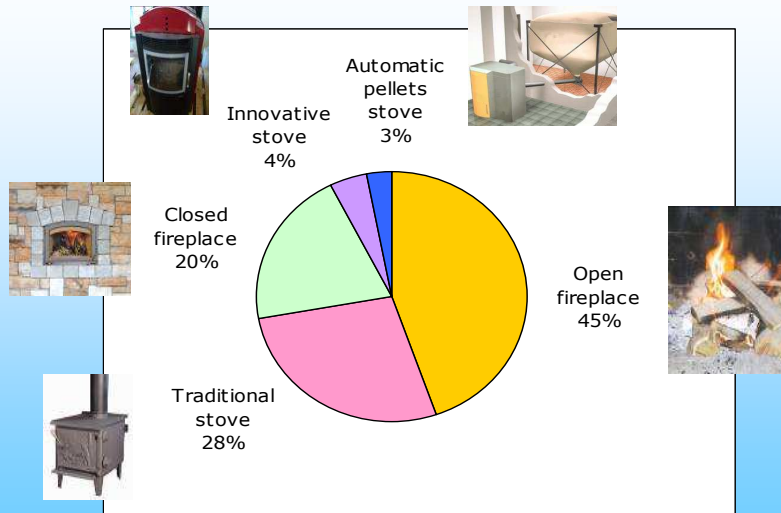
Regular use of wood, i.e. more than 4 times a year

 **about 20% of families**

Use of wood is more common

- in mountains and hills
- in single buildings
- in towns below 5,000 inhabitants
- for domestic heating (70%) rather than cooking (30%)

Distribution of wood combustion systems



An average of 1.3 appliance / household

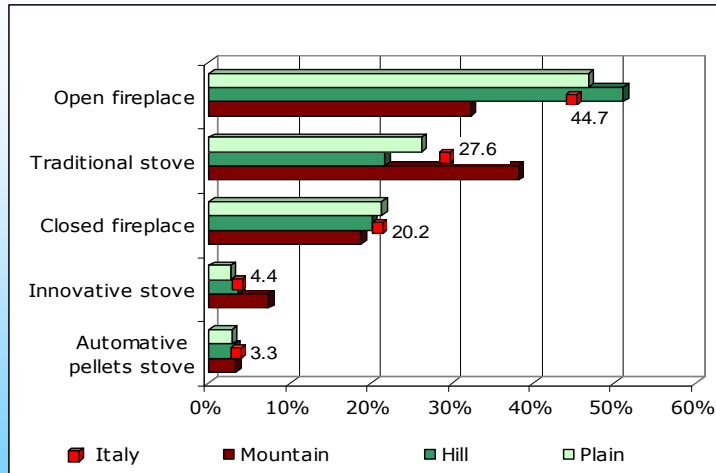
It is very important to distinguish among the different appliances as emission factors (and therefore emissions) of PM and toxic compounds vary considerably between different type of wood combustion appliances.

EF from a literature survey
(EEA Emission Inventory Guidebook + other sources)

	PM10 g GJ ⁻¹	NO _x g GJ ⁻¹	NM VOC g GJ ⁻¹	SO ₂ g GJ ⁻¹	CO g GJ ⁻¹	PAH mg GJ ⁻¹
Open fireplace	500	70	5,650	13	5,650	280
Traditional oven, closed fireplace or insert	250	70	1,130	13	5,650	280
Innovative low emission system and boiler	150	60	560	13	2,260	280
Pellets plant or BAT system burning wood	50	65	85	13	800	0.2
Natural gas	0.2	50	5.0	0.5	25	n.a.
Gas oil	5.0	50	3.0	100	20	75
Fuel oil	40	150	10	150	16	75

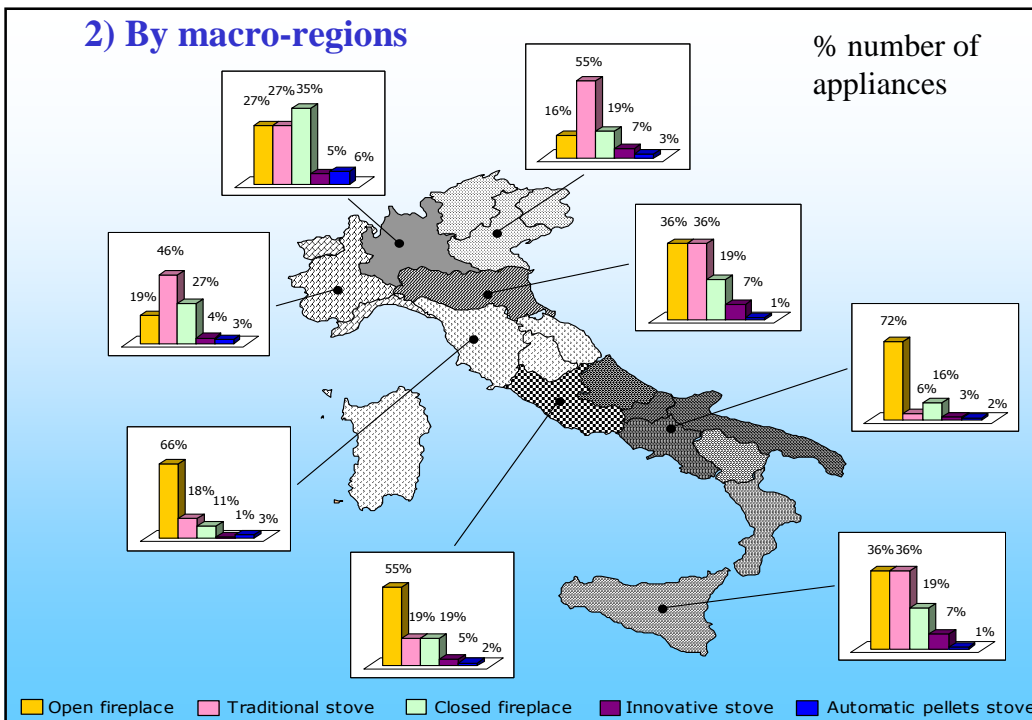
However, EF from natural gas and gas oil are much lower than the best EF from wood burning

Distribution of wood combustion systems: 1) by altitude



Stoves are more used in the mountain whereas the open fireplace is more common in the hills.

2) By macro-regions

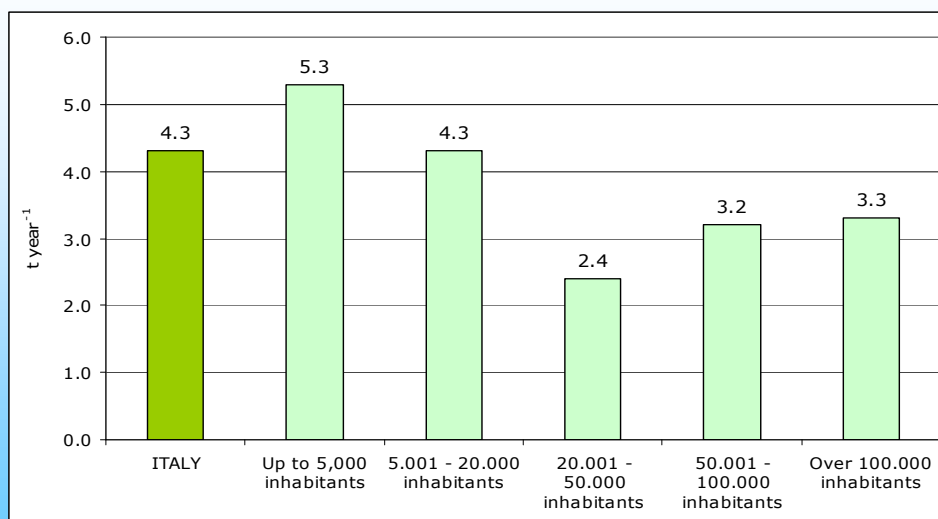


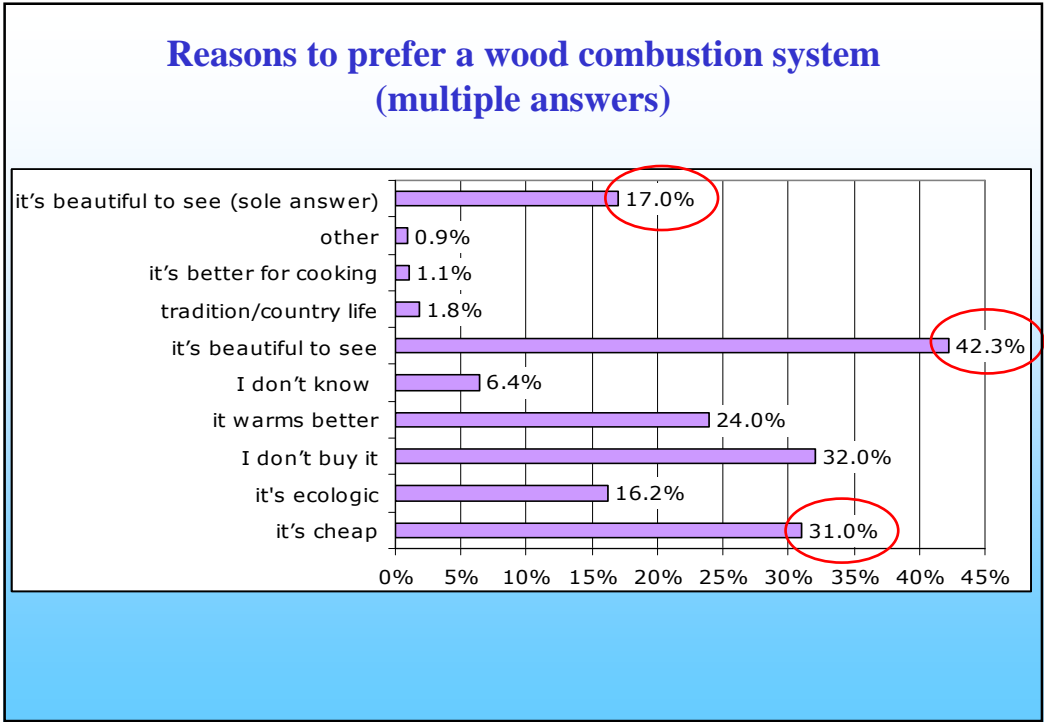
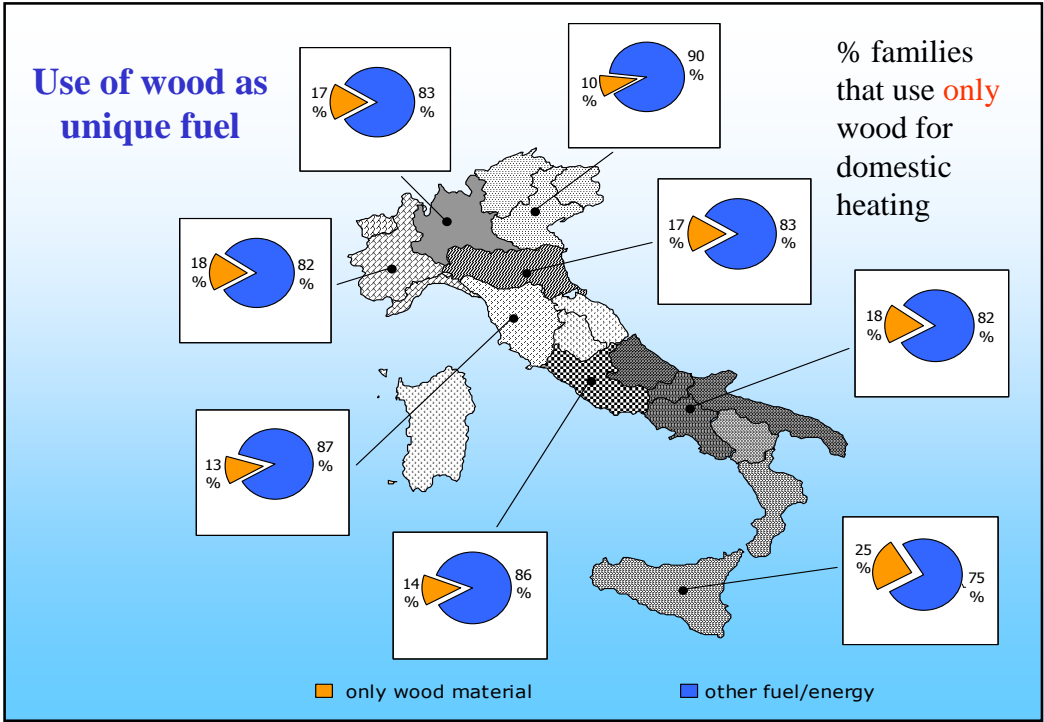
Wood consumptions for household heating in Italy (t/y) about 19 Mt/year in 2006

Wood consumptions – by macro-regions

	Households	%	Wood consumptions t	%	Wood consumptions per household t
ITALY	4,432,419	100 %	19,119,481	100 %	4.3
Piemonte + Liguria + Valle d'Aosta	480,115	10.8 %	2,268,662	11.9 %	4.7
Lombardy	594,396	13.4 %	2,034,035	10.6 %	3.4
Veneto + Trentino A. A. + Friuli V. G.	656,140	14.8 %	3,112,048	16.3 %	4.7
Emilia Romagna	271,260	6.1 %	932,336	4.9 %	3.4
Toscana + Marche + Umbria + Sardegna	752,458	17.0 %	3,461,665	18.1 %	4.6
Lazio	404,453	9.1 %	1,707,416	8.9 %	4.2
Abruzzo + Molise + Campania + Puglia	782,329	17.7 %	3,350,698	17.5 %	4.3
Sicilia + Calabria + Basilicata	491,269	11.1 %	2,252,622	11.8 %	4.6

Wood consumptions – by size of settlements

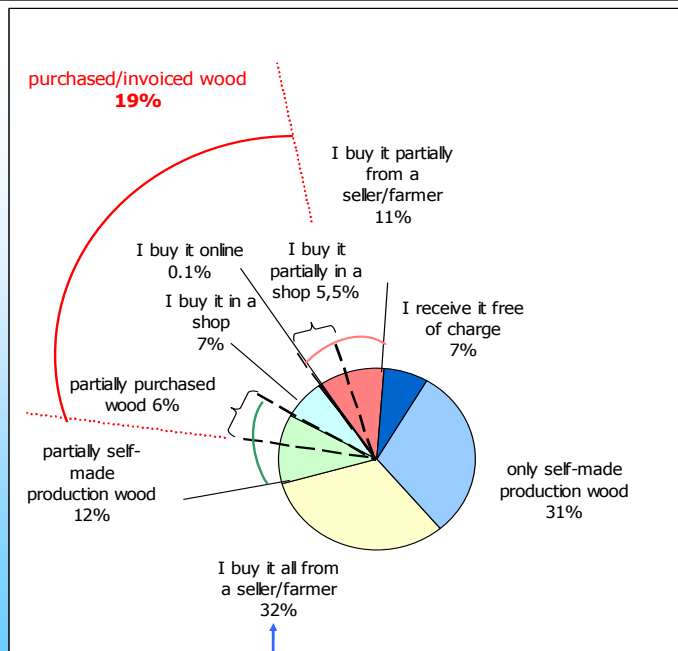




Supplying means

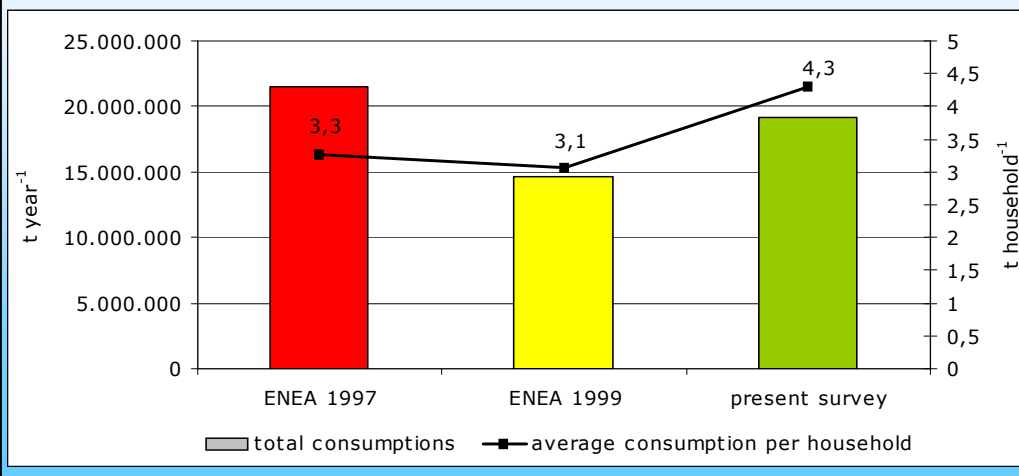
Approximately a balance between self-made production and purchase.

Only \cong 20% of wood burnt comes from sales channels, as invoiced or purchased (\cong 3.8 Mt vs. 20 Mt).

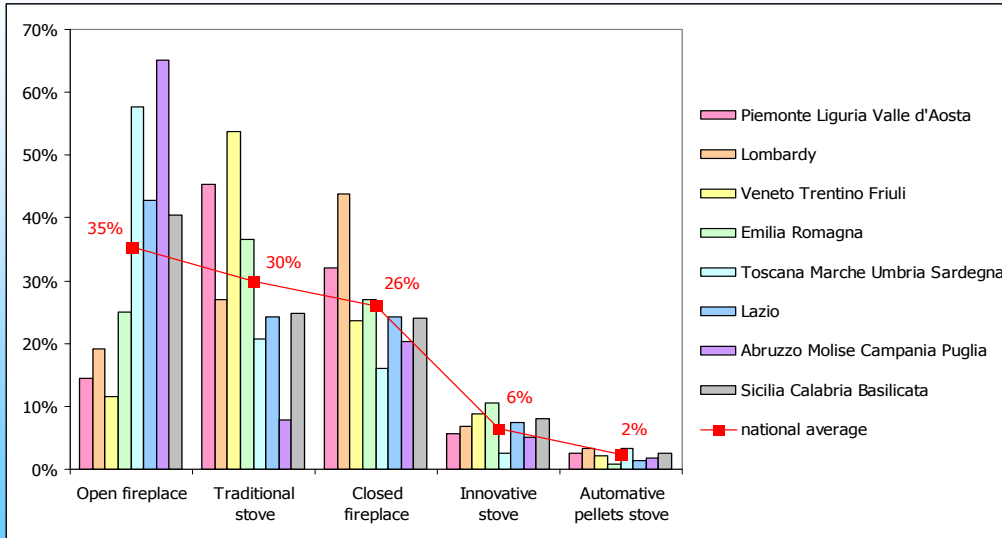


Farmers don't release a receipt...

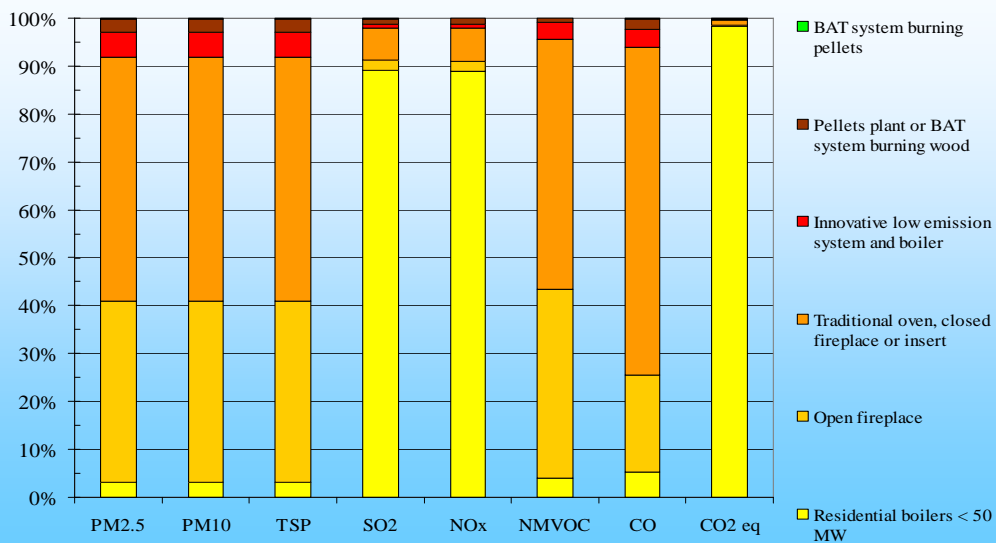
Comparison with previous surveys



Results - wood consumptions by appliance (%)



Lombardy 2005 emissions from domestic heating, by type of appliances



Critical points

- Results of this research give an estimation of wood use for domestic heating throughout the Italian territory but data are not available for all regions at the required detail (wood consumption by appliance). Regional emissions can therefore be over/underestimated.
- Problem of CATI methodology: a person could under/overestimate his own wood consumption.
- Data control is needed: 1/3 of the sample, that doesn't give information on the amount of wood used, has been estimated by an average value of consumption per heated surface unit and/or by number of working hours of the appliance. Outliers, inconsistent wood consumptions and families that did not answer have been corrected with average values by layer.

Production / consumption comparison 1/2

Official data on wood production

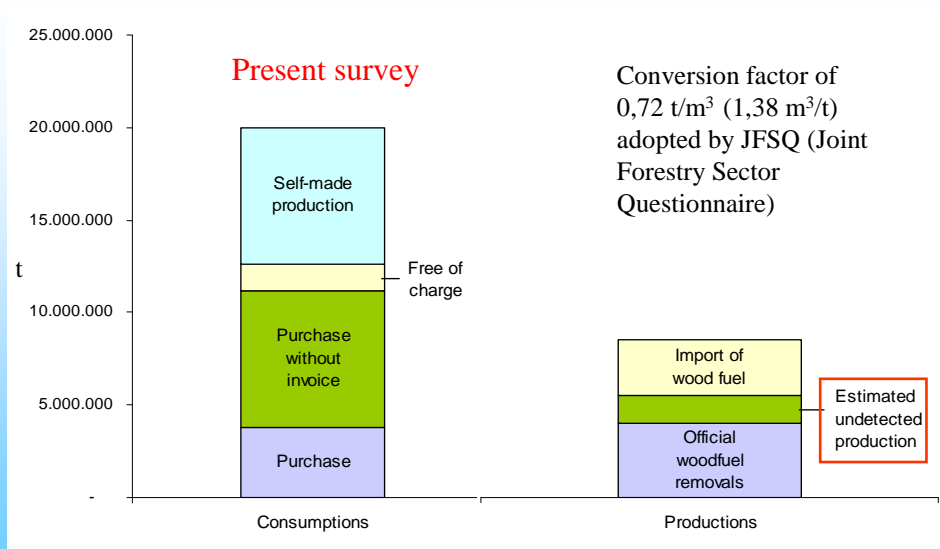
Official woodfuel removals (ISTAT, Italian statistic national institute):
5.600.000 m³

Imports of wood fuel* (Eurostat Prodcom statistics): 4.400.000 m³

Estimated undetected production (Italian statement on potential wood supply): 2.000.000 m³

*Imports include residues, chips and particles, wood charcoal.

Production / consumption comparison 2/2



Wood production underestimated: removals not recorded and/or quantities imported under different classes.

Comparison with data provided by the Wood Resource Balance 2005

ITALY

Energy use:
9.729.000 m³
(7 Mt)

0% Power and heat
0% Industrial internal
0% Private households
100% Undifferentiated energy use

No data previously available

Private households energy use from present survey: 19 Mt

FRANCE

Energy use:
50.125.000 m³
(32 Mt)

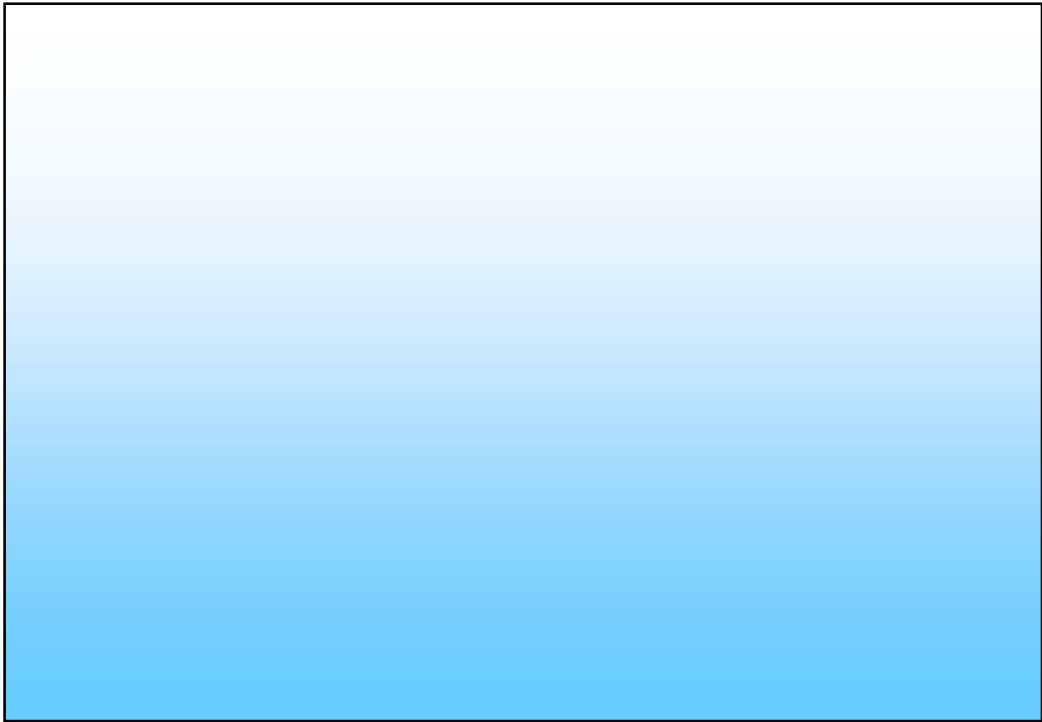
1% Power and heat
8% Industrial internal
74% Private households
18% Undifferentiated energy use

Lessons learned 1/2

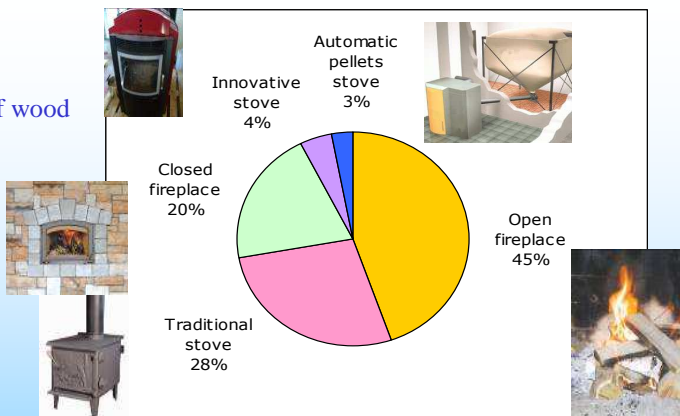
- Statistical analysis of data collected from 5,000 families with CATI techniques has provided a better knowledge of Italian wood consumption for domestic heating.
- Results of the present research are comparable with previous surveys, and provide also useful details on used types of combustion installations and regional split of wood use.
- This study, even if set with different objectives, evidences great discrepancies between fuel-wood consumption and the amounts of production (removals) and imports. This gap, already known by the specialists in the field, makes it urgent the launch of new “ad hoc” surveys and the revision of current statistics.

Lessons learned 2/2

- The importance of the quantification of wood use in the domestic sector is of great importance also for atmospheric emission inventory
- Information on the use of different appliances is of great importance, as PM and toxic emissions are directly linked to combustion technologies and are higher for old stoves and fireplaces.
- The research confirm that traditional wood systems (open fireplace, traditional stove) are widespread on the national territory as they represent more than 70% of the total, but trend in sales of innovative devices is growing.
- CO₂ savings due to the photosynthetic origin of wood (about 2 % of CO₂ emissions) are far lower than PM, VOC and PAH emission increase due to wood combustion (about 30 % of PM10 emissions).
- Innovative devices could lower PM and toxic emissions if older appliances are changed out.



Distribution of the number of wood combustion systems



Wood consumption by wood system

Important because emission factors are heavily dependent on the type of wood appliance used

Wood consumptions by appliance (%) - Italy

With multiple users

Basis: habitual users	TOTAL	TRADITIONAL WOOD SYSTEMS	Open fireplace	Traditional stove	INNOVATIVE WOOD SYSTEMS	Closed fireplace	Innovative stove	Automotive pellets stove
Households	4.432.419	3.346.275	2.226.541	1.401.839	1.454.370	1.109.895	230.717	173.748
average	4,31	4,39	4,25	5,30	5,37	5,63	6,44	3,76
standard deviation	5,07	5,29	5,57	5,38	5,64	5,65	6,20	5,25
Wood consumptions	19.119.481	14.673.416	9.458.346	7.422.738	7.802.695	6.247.599	1.484.664	653.119



Basis: habitual users	TOTAL	TRADITIONAL WOOD SYSTEMS	Open fireplace	Traditional stove	INNOVATIVE WOOD SYSTEMS	Closed fireplace	Innovative stove	Automotive pellets stove
Households	4.432.419	3.346.275	2.226.541	1.401.839	1.454.370	1.109.895	230.717	173.748
estimated average	4,31	3,73	3,04	4,08	4,56	4,48	5,28	2,61
Final wood estimates	19.119.481	12.481.511	6.758.616	5.722.894	6.637.970	4.966.975	1.218.353	452.642

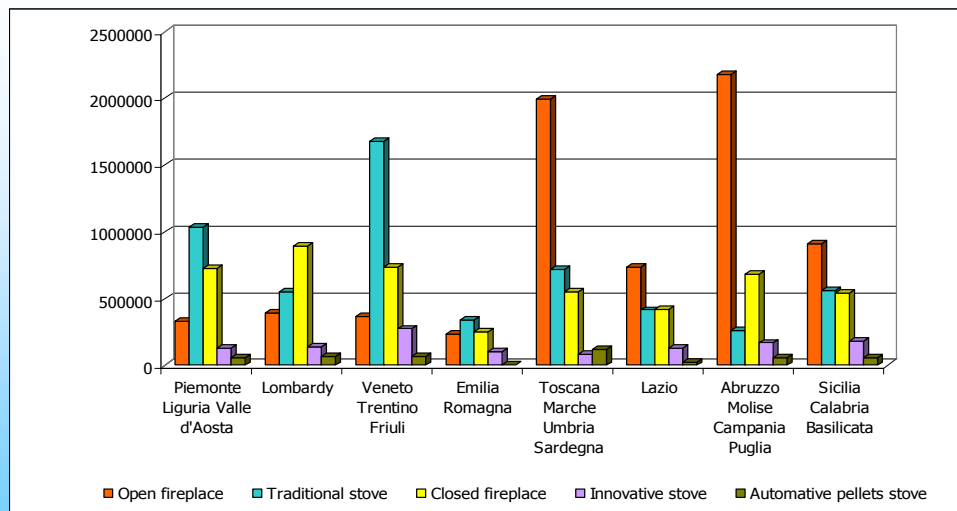


Regional consumptions by appliance (%)

Hypothesis: average national consumptions per household are the same at a regional scale (who utilizes wood uses the same average national amount, difference is in the number of households). The same procedure allowed to obtain the regional distribution of consumption by appliance, simply by substituting the number of households in each region.

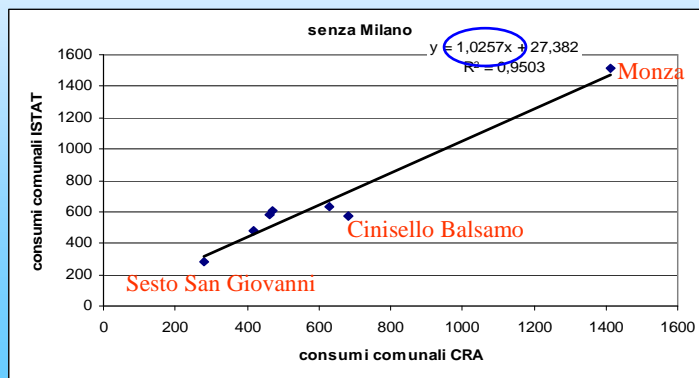
Basis: habitual users	NIELSEN REGION							
	Piemonte Liguria Valle d'Aosta	Lombardy	Triveneto	Emilia Romagna	Toscana + Marche + Umbria + Sardegna	Lazio	Abruzzo + Molise + Campania Puglia	Sicilia + Calabria + Basilicata
<i>NET: TRADIT. SYSTEMS</i>	345.470	340.940	486.637	201.278	657.534	320.557	635.692	358.166
Open fireplace	120.309	179.611	118.893	111.635	578.886	246.229	616.506	254.473
Traditional stove	273.418	170.128	409.842	108.433	159.008	103.014	56.664	121.333
<i>NET: INNOVAT. SYSTEMS</i>	189.214	325.692	209.710	102.290	149.640	128.608	193.736	155.481
Closed fireplace	161.572	256.501	152.951	74.227	102.794	98.841	156.620	106.390
Innovative stove	23.961	32.354	48.398	23.660	13.941	25.080	32.300	31.025
Automotive pellets stove	22.105	41.273	22.191	4.403	32.905	9.431	23.374	18.066
TOTAL	480.115	594.396	656.140	271.260	752.458	404.453	782.329	491.269

Wood consumptions by appliance (t)



Great differences among macro-regions both in values and in uses of appliances.

Comparison between domestic wood consumption in estimated by the CATI 2007 (Milan Province) survey and from data on surface of house that use wood according to the 2001 Italian Census (assuming 50% of energy need covered by wood in case of wood + gas)



Correlazione fra i consumi stimati (superfici miste: 40% durata per legna, senza Milano)

