Trends in Pellets Utilisation : Prospects and reasons for variations in Italy, Spain and Greece

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Task 3.2.1

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3. Introduction and executive summary

The three studied pellets and biomass markets contrast greatly in their level of development and the barriers they face. And yet they have striking similarities, which allows for the consideration of common market strategies. Some of these similarities include:

- A general lack of unused wood residues for pelleting, and an availability of unused agricultural residues.
- A lack of market information due largely to a low level of interest in pellets on a national level
- A relatively small penetration of pellet boilers (most markedly in Spain and Greece)
- A low level of international integration of pellets markets leading to sharp price fluctuations and local price distortion.
- Significant logistical barriers to the collection of residues in Italy and Greece. In the case of wood residues, mountainous regions and a low proportion of actively maintained forests results in a limited availability of residues. In the case of agri-residues, dispersed and small plots of land make residue collection labour-intensive and expensive.

The analysis of this report is divided into 3 country reports. The result is an in-depth country-by-country market analysis, customised according to the particularities of the respective national market.

3.1. Italy

To summarise the data and impressions collected the analysis of the Italian pellet market, it can be stated that the Italian pellet market is enjoying a steady and stable growth. This success is however held back by the lack of a precise legislation to guide the development of the market.

The pellets production industry has grown constantly during recent years, but has now reached its first upper limit. This limit results from the now exhaustive exploitation of waste from the furnishing industry. For further growth, new sources of raw material must be tapped into. The levels of pellet produced have constantly increased. However, the pellets price has followed a similarly upward trend, albeit to a lesser extent. This trend is due primarily to the difficulties in finding the raw material that is no longer seen as a waste, but as an increasingly scarce resource. So, to continue producing pellets in an economically feasible way, the pellet industry must explore new possibilities. These possibilities must be found in new ways of collecting wood from forestry management and, above all, in producing pellets from agricultural residues. This kind of production requires investment and a precise strategy, both at the national and the European level. The pellet industry requires precise standards about the characteristics of pellets and funds to stimulate technological research.

3.2. Spain

Spanish biomass pellet market with energy purposes is nowadays small. This has made difficult data collection because institutional entities have got little information on it and companies involved in the market do not want to provide information to avoid giving information to competitors.

High quantities of biomass residues (agricultural, forestry and industrial ones) are produced in Spain and could be used for energy production, for example in the form of biomass pellets. The Plan to Promote Renewable Energy Sources in Spain seeks to significantly increase those quantities by the 2010 horizon. No reliable estimations have been made for waste production and consumption. In addition, the biomass waste market is not regulated and many raw materials are scarce while others exist in excess. Consequently, there is low reliability of both quantities and prices of resources, as well as high volatility of waste prices.

The biomass pellets market has still a low development due to several barriers that will be analysed in further Deliverables of the project. Some of them have been pointed out in this report, as for example the competition for wood industrial wastes with board manufacturing.

However, the pellets market can be seen to face imminent change: in addition to the few well established companies that produce and commercialise pellets, our investigations have succeed in finding several new market actors interested in producing pellets, distributing pellet stoves or adapting their equipment to pellets. Research centres and universities, as well as national and local energy agencies are also interested in the subject, and are trying to overcome their current, individual barriers. Moreover, raw material diversification is starting to be considered, as the present report also shows.

Finally, further growth of the Spanish pellet market can be expected, due to other European countries' markets' development and the growing interest of a wide variety of actors and stakeholders.

3.3. Greece

The total biomass contribution, as primary energy, is presently estimated at 1 Mtoe/year, and can considered as, more-or-less, stable in the short run, as the two opposing major tendencies balance each other:

- Negative trend: gradual decrease in the use of traditional bioenergy (fuelwood)
- Positive trend: slow growth of new bioenergy applications (agro-industrial residues)

More than 95% of the above bioenergy contribution is in the form of solid biofuels, which are mostly (by more than 90%) used for energy production without any type of refining or upgrading. Within the present bioenergy use in Greece, forest-derived woody biomass does not represent the dominant type of solid biofuel. Greek bioenergy is mainly based on agriculture-derived sources.

The main type of bioenergy use in Greece is, still, the traditional, rural one, i.e., for space heating in farm-houses, equivalent to 2-3 kW thermal per house, requiring 2-3 t of solid biomass/year (fresh amounts of forest or tree crop derived wood). This form is in a long-term, slow decline, following corresponding socio-economic changes in rural areas.

This is followed in importance by the use of agro-industrial residues - such as olive kernels, cotton-gin wastes, fruit processing wastes, etc – mainly for process heat generation at agro and cottage industries, based on the utilization of their own wastes and residues.

The main obstacles identified for the deployment of the use of solid biofuels in Greece are the following:

- Resource: Availability, seasonable patterns of generation, collection, storage and handling aspects
- Technical: Maturity of certain conversion technologies (e.g.: gasification), role of inorganic constituents (e.g.: ash melting)
- Economic: High initial capital required, high interest rates, lack of venture- and risk capital

4. Italy

4.1. Sources of wood and agri-residues

4.1.1. Market overview

For any analysis of the pellets market in Italy, an overview on the biomass produced and potentially produced on the territory is necessary. This potential is quantified considering both forestry and agricultural cultivations.

Starting from the forestry, one third of Italy's land area is covered by forests: an area of about 10,000,000 ha. So large a surface offers enormous potential. The total volume of biomass produced by this area reaches billions of m^3 , a value similar to that of Germany and France. Of this volume, only 25% is covered by high forest, while the 42% is covered with coppice and another 26% by shrubbery and riparian trees.

The productivity level of the Italian forestry is one of the lowest in the European Union: 3m^3/year/ha (France, Spain and Portugal have 4 m^3/year/ha, Germany and UK 5.6).

With these premises, we have taken the surfaces covered by the different tree species and then we have multiplied these for the economic residues obtainable from hectare; in this way we obtained the total residues that can be potentially and sustainably exploitation: **158,000,000 quintals**.

This enormous quantity must be rectified with the following considerations:

- The major part of the woods is located in mountain or hilly areas, hardly approachable with mechanic vehicles.
- 66% of the Italian wood belongs to private owners and generally have small dimensions (3 ha in average). The small wood plots included in agricultural areas constitute 24% of the total agricultural area. The great subdivision of the forestry property is another element that makes the productive use of the wood difficult.
- The Italian wood is not of a good quality, because 60% of it is burning wood. However, in the last fifty years, the wood harvest for working purposes has been remained constant, while the wood harvest for burning has continually declined.
- The total felling surface (areas subjected to forestry utilization) amounted to 130,000ha/year, a value that has remained constant over the last 20 years.

Considering the four points above, the wood production effectively used amount only to 9 million m^3, equal to 5 million tons of seasoned wood. This quantity covers only a minimum of the Italian industry's needs. Moreover, the production of useable wood is located above all in Northern Italy (75%).

In addition, there are agricultural residues, which in Italy have an even greater potential. In fact, by multiplying the harvested area by the average value of residues produced from each relevant culture, we obtained an estimated quantity of 124,896,817 quintals. In Italy

there is only one wide plane, the Padana plane; the rest of Italy is studded with many small planes. So, as in the previous case, there is a problem concerning the gathering and transport of the residues. The small dimensions of the plane and the strong subdivision of the property are elements that make the harvesting and the residues collection on large scale very difficult and economically inefficient: the farmers are wary and so it's very difficult to convince them to unite in associations or cooperative society in order to collect harvesting residues on large scale.

Region	Type of residue[1]	Current utilisation of residues	Output (tons / year)
PIEMONTE	C	2,000,000	2,223,700.00
VALLE D'AOSTA	C		3,890
LOMBARDIA	C		1,118,988
TRENTINO	C		151,036
VENETO	C		1,590,906.00
FRIULI-VENEZIA GIUILIA	C		539,350
LIGURIA	C		46,510
EMILIA-ROMAGNA	C		1,616,783
TOSCANA	C		639,500
UMBRIA	C	207,400	639,611

1 A = Forestry residues (forest thinning and pruning from sustainable forest management, forest arising) and trimmings from city trees; B = Wood process residues from industrial uses (virgin and treated materials); C = Agricultural residues (straw and stalk from oil and cotton plants, etc.)

Region	Type of residue	Current utilisation of residues	Output (tons / year)
MARCHE	C		874,964.00
LAZIO	C		738,108
ABRUZZO	C		436,475
MOLISE	C		323,982
CAMPANIA	C		741,723
PUGLIA	C		2,305,974
BASILICATA	C		558,389
CALABRIA	C		821,646
SICILIA	C		1,670,964
SARDEGNA	C		515,662
TOTAL AGRICULTURAL		---	**17,558,160**
PIEMONTE	A	44,136	300,000
	B	519,437	522,572
TOSCANA	A		274,000
	B		176,500
TOTAL WOOD			**15,850,000**
TOTAL			**33,408,160**

Figure 1 : Potential of agricultural and wood residues

4.1.2. Wood and residues: import and utilisation

A complete framework of the quantity of wood utilised in Italy required a valuation of the import/export of wood and an overview on the ways in which it is utilised. **Italy imported 1,878,613 tons of wood** in the year 2000, of which 530,274 defined as “sawdust and waste”(source: ISTAT and Federlegno-Arredi). The projected import is as follows:

	Tons of wood
Firewood	355,373
Chips	992,971
Sawdust and waste	530,274

Figure 2** : **Import of wood to Italy

This amount has probably increased in the following years, considering the wood imported specifically for power plants and CHP. In fact, about 1,000,000 tons of wood has been imported in the year 2002 from South America specifically addressed to two power plants in Calabria.

Moreover, a further thing to consider is the **packaging industry** that in Italy is a lobby of great power and moves many profitable interests.

The two most important groups are Saviola and Frati. Saviola, in particular, recycles about 1,560,000 t/year of wood residues, coming from municipality companies, sawmill and dedicated cultures; Saviola imports also about 480,000 t/year of wood residues from France and Germany. Considering that Saviola and Frati covers about the 60% of the packaging industry market, the total wood residues recycled would amount to 3,700,000 t/year. This data clashes with that provided by CONAI (National Packaging Consortium). According to this evaluation, in 2002 have been recycled 1,050,000 tons of wood packaging, equal to 42% of the products commercialised (2,500,000 of tons of pallets and wood industrial packaging). However, whatever is the amount of wood recycled by CONAI, these wood residues constitute an alternative use respect the energetic one. This conflicting usage of the residues is a further obstacle for the pellets manufactures in findings biomass.

The previous data must be added to the residues produced by the **furnishing-wood industry**. This sector produces every year about 6 millions of tons of production rejects, of which about 4,700,000 are from virgin wood, and the remaining part from treated wood. These data are taken from a research conducted by AssoLegno (National Association of forestry industries) for the year 1997, but can be confirmed for the following years.

Summarizing, in Italy there are available **about 7,000,000 of tons of wood residues**; these data exclude a good share of the residues recovered by municipal companies from trimmings and other sources. Of these 7,000,000 tons the packaging industry uses about 3,700,000, while only little more than 500,000 tons are used for energetic purposes; in particular, **it can be estimated that 200,000 t/year are used for producing pellets.**

In this way it is very difficult to estimate the uses of the remaining gap of about 3,000,000 tons. To complete the overview, we must underline that the wood residues are utilised also by industries that produce tannin (above all from chestnut) and compost. However, it seems that there could be a great potential for pellets uses.

WOOD RESIDUES AVAILABLE	WOOD RESIDUES USED
6,000,000 tons of wood residues derived from wood industries + About 1,500,000 tons of imported chips and waste + about 200,000 tons of wood derived from steelworks =	3,700,000 tons recycled by packaging industry + 250,000 tons for power plants fuelled with chips + 50,000-100,000 tons for district-heating plants + ***200,000 used for pellets production*** =
About 7,000,000 tons of wood residues from industrial uses	4,225,000 tons of residues utilised

Figure 3** : **Prospects of wood import and utilisation in Italy

4.2. Pellets production

4.2.1. Market situation

It has been very difficult to find data about pellets market development; this is mainly due to the problems in finding information on a market that is still in its first stage of development and that, as a consequence, it is not entirely structured. A complete and well functioned pellets chain, which unites all the actors taking part in the market doesn't exist in Italy; so the only "available" source of data is constituted by the market assessment conducted by the single market actors that are already in it, or that are about to enter in it. Logically, the market actors that have carried out this kind of research are reticent in delivering the resulting data.

Regarding the pellets from wood residues, it seems that they made their first appearance in Italy in 1994: to our knowledge, the pellets producer "LaTiesse" was the first in Italy to produce pellets. According to this, the pellets production during the year 1995 was estimated to be about 5,000 tons, that is the production corresponding to the dimensions of a medium sized plant. The evaluations for the following years have been conducted considering the number of pellets producers present on the market, other sources of information not being available.

During the years between 1995 and 1999 the market has seen a constant development that has brought the production to a value of approximately 70,000 tons.

The market has seen its major development in the last three years, with an increase of about 30-40% of the producers. During the research for PELLETS FOR EUROPE, 37 pellets producers have been reviewed. Many of them only established themselves in the last few years or in the last few months, and so are still in an early stage of development. Moreover, the market is in continuous upheaval, and so it is possible that other producers have eluded our research.

About twenty producers have been directly contacted and, even if reticent in giving out data on their production, a production that varies from 100,000 to 130,000 tons has been estimated for the year 2003. This large range is due to the fact that the larger producer has not given us a precise datum, but only a range; moreover, as previously mentioned, many producers are not be contacted.

4.2.2. Inventory of national producers/distributors

The pellets market has seen in Italy a slow but continuous development; even if its dimensions are still modest, it has seen a remarkable development above all in the last 4 years, in which it passed from about 20 operators to the actual 41. In particular, it can be observed a remarkable positive trend in the first months of this year (2003): many actors among chips producers and sawmills decide to enter in the pellets market, guessing the enormous potential of this kind of combustible.

The dimension of the pellets producers are very variable and so even the production varies a lot: the smallest producer has an output of 300 t/year, while the largest produces 25-30,000 tons/year. With this variability, the average production per producer is not a significant datum. There are only two large producers that produce more than 20,000 tons/year, “LaTiesse” and “Il Truciolo”, and others three producers that manufacture about 8-10,000 tons/year; all the remaining producers have very small dimensions. So, it can be observed an important feature of the Italian market: **the great majority of the producers are small producers with a field of action limited to a regional dimension.** A local stove or boiler producer agrees on with a local pellet producer the supplying of pellets for people that buy their heating equipments. So, this local pellets producer supply only local distributors or single local customers. Moreover, a stove producer usually tests its equipments on a specific pellets brand, and for this reason often provides the consumer with one kind of pellets. In fact, the use of different pellets can produce problems to stove and boiler.

Figure 4 shows the distribution of pellets producers in Italy and illustrates the evolution from 2000 to 2003. Nearly the 80% of the production is located in the North of Italy, where the producers of major dimensions are located. In the North Italy the Veneto region covers about the 35% of the market; in fact, the North-East of Italy is one of the most industrialised zones in the country and it is also a “wood-industrial district”, an area specialised in wood industries. With the market growing, the proportion covered by the North Italy has in parallel shrunk, passing from 81.90 to 77.11%; this decreased has been in favour of the producers located in Central Italy, where the production has increased of about 4.50%. This is significant of an industry that is going through a period of expansion. But this also testifies that the pellets industry is developing through the traditional “Italian model”: a model that sees the presence of many small enterprises (often family owned) widespread on the surface, and not big manufacturers as, for example, in the American case.

The production of pellets is the principal activity for about the 60% of the producers, while the remaining 40% produces pellets only as secondary activity, to exploit and give value to residues otherwise without value.

Probably many producers must be added to the 41 registered: in fact, many sawmills and wood industries utilised the residues originated from their production to produce pellets for their own consume. Considering this last category of pellets producers, the number can

increase to nearly 100! (but this datum is not confirmed through statistical research, it's merely indicative).

In Figure 1 are represented the single Regions with the producers percentage compared to the production percentage. The percentages calculated in Table 8 and in Figure 1 consider only the producers that have responded to our interview (27 producers on 41); however the producers that have not responded are proportional distributed among the regions.

Regions	Producers			% Producers		
	2001	2003	Δ	2001	2003	Δ
Lombardia	9	10	+1	19.10	15.37	3.73
Veneto	5	4	-1	54.70	34.81	-19.89
Trentino Alto Adige	2	2		0.40	4.60	-4.20
Friuli Venezia Giulia	2	3	+1	7.20	18.39	11.19
Piemonte	2	2		0.50	1.97	1.47
Emilia Romagna		1	+1		1.97	
NORTH	20	22	+2	81.90	77.11	-4.79
Toscana	3	4	+1	4.00	6.77	2.77
Umbria	2	2		3.40	2.63	-0.77
Abruzzo	3	5	+2	6.50	9.00	2.50
Lazio	1	1				0.00
Marche		1	+1			
CENTRE	9	13	+4	13.90	18.40	4.50
Basilicata		1	+1		0.99	0.99
Campania		2	+2		1.97	1.97
Molise	2	2		0.80	0.54	-0.26
Puglia	1	1		3.40	0.99	-2.41
SOUTH	3	6	+3	4.20	4.49	0.29
TOTAL	32	41	+9	100.00	100.00	

Figure 4 : Pellets production by region (Italy)

(Source: CTI and ETA Renewable Energies)

People employed for producing pellets nationally are about 80, with an average number of two people per firm. This datum is difficult to estimate, because of the variability in the enterprise dimensions: there is the "family enterprise" owned by one entrepreneur assisted by his familiars, the small enterprise with one worker that supervises 2 machines, and there is the big enterprise with 20 workers.

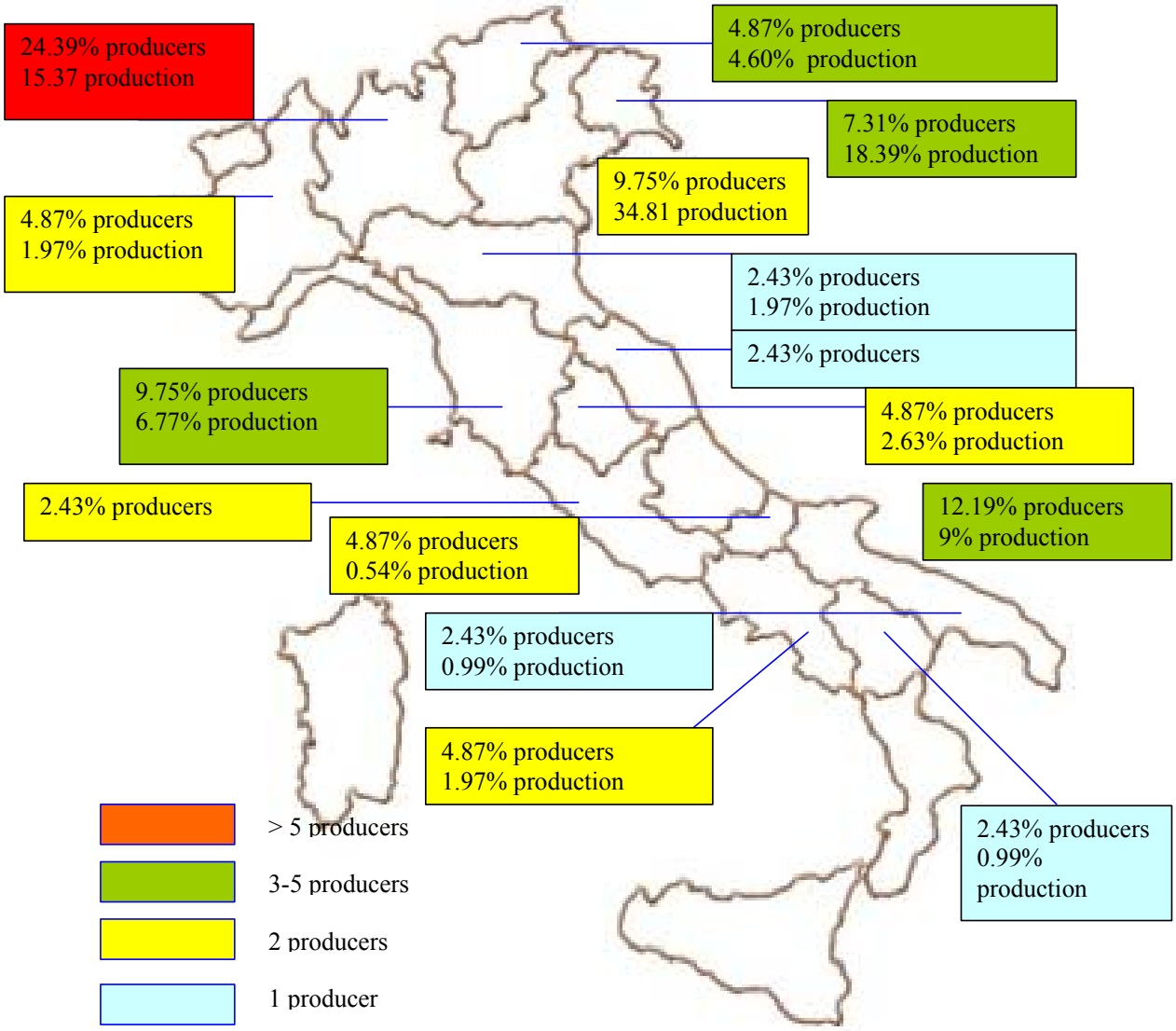


Figure 5** : **Map of producers and production distribution by region (Italy)

The national consumes of pellets have been estimated by CTI in 2001 in about 150.000 tons/year; a revision of this numbers just done indicates 210,000 tons of pellets consumption for the year 2002/2003. Of this amount, about 160,000 tons are produced in Italy, while about 20-50,000 tons/year are imported. As we can see, the pellets consumption has increased of about 40% in only one year, in parallel with the increase in the number of producers. The two foreign brands more diffused and imported in Italy seem to be the Spanish Ecoforest (7-8,000 tons/year) and the Austrian Leitinger (10,000 tons/year). Data about import of pellets in Italy are very difficult to estimate, since a precise product definitions don't exist for pellets: pellets are imported under different product descriptions: firewood, chips, etc.

Regarding the pellets produced from agricultural residues, until now only one producer is present on the market: ENERGIAGRI. It has been started production for only 4-5 months and has an expected productivity of 12-15,000 tons of pellets per year. However, there are many producers that are experimenting in laboratory the production of pellets from agricultural residues.

The mood prevailing among the pellets producers is conflicting, but prevail a sort of pessimism: among the contacted person (20 producers), only 3 were optimistic about the future developments, while the others were worried. All the evidence makes it clear that many kind of actors are trying to join in this market, guessing the potential that pellets will probably have in the future. One time they have joined in the market they face the problems typical of the Italian market. The rules of the free market will decide what actors survive.

In short, the key problems identified are:

1. the heavy investments required, above all in the initial investment;
2. In some cases producers meet difficulties with the pelletising machine: this kind of machines break easily and it is required many times to repair them.
3. the increasing difficulties encountered in finding raw biomass; as we have seen, this is due both to the difficulty to collect biomass among many small properties and to the competition of wood recycler;
4. the presence of district heating plants fuelled by chips that take away biomass potentially useful for pellets;
5. the need of governmental and institutional incentives;
6. the consumers' scarce knowledge of the final product.

In these conditions, many producers are now producing without profit, burdened by the heavy investments sustained.

Passing to examine the **price**, first we must do some preliminary considerations, trying to design its evolution: we don't know the exact pellets price for the years between 1995 and 1999. A survey conducted among producers has not given a homogeneous result, there are dissonant opinions: while for some producers the price has increased, for others the price has remained substantially stable. However, if we consider the conditions prevailing in the Italian market, we can reasonably assume that the price has somewhat increased, with a remarkable leap above all in the years 1999-2000. In the last two years the price has been stable, but a further increase can easily be foreseen shortly. This "leap" is due to the increasing difficulties in finding the raw material from which the pellets are produced. In fact, in the last years there has been a general "run" for wood waste: as a consequence of the increasing importance that biomass in general will have in the coming years among renewable energies, sawmills and wood residues in general are seen as a precious and costly resource. With the development of the pellets market, the request for wood residues originated both from industrial residues and from forestry management is continuously augmented, and it has become a scarce resource. Moreover, there is the competition of the wood recyclers, which utilize the industrial residues for making panels and pallets. This competition has brought an increase in the price of raw materials, and will probably bring to further increases in the future.

After these considerations, we can begin to quantify the price. In previous research studies (CTI, PROBIO Program) it has been quantified within a range of 0.21 and 0.26 €/Kg for the years 2001-2002. Bearing in mind the previous considerations, we can quantify the price for the period preceding the year 2000 to 0.15-0.20 €/Kg. In our research, for the year 2003, a price lying within a range between **0.25 and 0.35 €/Kg** prevails in the **retail market**, depending on season variations. There are, however, lows of 0.18 €/Kg and peaks of 0.40 €/Kg. These extremes show a market that is not yet fully structured, which present differences at a regional level and, in the same region, among different producers.

For the wholesale market the price varies between 15 and 25 € per quintal.

Production Costs (raw material included)	70-80€/kg
Wholesale Price	110-150€/kg
Retail Price	210-260€/kg

Figure 6 : Production cost and price for pellets in Italy for 2001-2002

(Source: CTI, Biofuels National Program (PROBIO))

Year	Pellets sold (tons)	Price (Euro/Kg)
1990	5,000	0.19
1995	˜10,000	0.19-0.21
1996	≥10,000	
1997		
1998	≥50,000	
1999	≥70,000	
2001	85-95,000	0.21-0.26
2002		
2003 (projected)	100-130,000	0.15-0.40

Figure 7 : Annual evolution of pellets sold (Italy)

A recent research conducted by CTI in the framework of PROBIO project has tried to do a study to analyse the “pellets chain” from an economic point of view; the study aims to show the economic sustainability of a typical plant according to the Italian conditions. From the analysis it is emerged that the physical and economical characteristics of the biomass utilised strongly influence the production profitability. The factors that most influence the profitability are:

- **type of biomass:** determines the structure of the plant and the relative initial investments. A plant that utilise sawdust is different from one that utilise waste, and is even more different from one that utilise brushwood. Even if in Italy

sawdust is the most used source of biomass, its availability is very limited and so the future production of pellets will depend from the brushwood available.

- **Price of biomass:** due to the limited availability, the cost of sawmill is increasing, above all in the North-East Italy, where the great majority of the sawmills are located; in these regions the price of sawdust has reached 50 €/tons, because of the presence of the strong competition of the panels industry. The maximum purchasing price for biomass, if pellets production is to be profitable, is 28-29 €/tons, a price that is often exceeded in Italy for brushwood.
- **Moisture:** the presence of drying systems weighs upon the initial investment costs for about 16%, and then weighs upon the energetic costs.
- **Costs for transport:** the costs are equal to 17% for sawdust and waste, considering a distance of 100km.

In Table 11 the parameters taken into considerations for the financial analysis are listed:

Parameter	Value	Unit of measurement
Plant capacity	1.85	tons/hour
Annual functioning hours	3850	hours/year
Years of utilisation	10	Years
Maintenance coefficient	1.5	%
Real interest rate	5	%
Cost for electricity	0.159	€
Storage Costs	125000	€
Workers	2	
Final moisture of pellets	12	%
Initial moisture of biomass	40	%
Transport, distance covered	100	Km
Price of sawdust	23	€/tons
Price of waste	22	€/tons
price of brushwood	36	€/tons
Price of wholesale pellets	135	€/tons

Figure 8 : Parameters considered for the financial simulation of a pellet plant in Italy

The study shows that sawdust with a low percentage of moisture is the raw material that, at the present, offers the highest margins. The utilisation of brushwood is convenient only if the place in which the biomass is collected is near to the pelletising plant, and if there is a major wholesale price for pellets.

	With Dryong system		Without Drying systems	
	IR	TIR	IR	TIR
Sawdust	0.56	13%	2.3	38%
Waste	0.46	12%	1.98	33%
Brushwood	-0.7		0.84	16%
Brushwood. Particular case	0.11	4%	1.78	28%

Figure 9 : Profitability indices for Italy

- ***IR: Profitability Index: express the profit (or the loss) of the investment for investment unity.***
- ***TIR: Internal Rate of Profitability: express the interest at which the plan pays the invested capital.***

Raw Material	With Drying system	Without Drying System
with sawdust	+	+++
with waste	+	+++
with brush from wood	-	++

Figure 10 : Results of the Italian pelletising market assessment

- ->TIR<10%;
+ -> 10%<TIR<20%
++ -> 20%<TIR<30%
+++ -> TIR>30%

Until now the Italian pellets market is very confused and with little structure. This situation can be attributed to the lack of a precise reference norm for pellets products: there is no precise standard that caracterised pellets, and so the product can be of bad quality, a thing that negatively influences the attitude of consumers. In particular, the lack of precise standards prevents the formations of different classes of products with differt prices, as occures in other countries with a more developed market. So, all the actions that increase the information level for the actors present on the market should be encouraged. CTI is going in this direction, studying in these month a proposal for a normative that reflect the CEN/TC 335.

4.2.3. Pelletising equipment manufactures

As can be seen in the following table, there are 4 national manufactures in Italy (Larus, Kemix, Bollareto and La Meccanica) and 2 importers/distributors (both of CPM plants). Moreover, there is an engineering society, whose principal activity is to study the necessity of a particular firm that wants to install a particular plant; this engineering society is in association with “la Meccanica”, that provides pelletising equipment.

In many cases the pellets producers assemble their own the plants, combining the parts of different trades.

From talking with these manufacturers, we know that 2 of them have had many problems in operating plants that could function reliably. In fact, they have firstly tried to apply in plants for wood and agricultural pellets the same techniques utilised for producing animal feed pellets.

There are also problems in projecting plants that produce pellets from virgin biomass with a moisture percentage major than 35%, in order to not use drying systems. It seems that this particular technique works well in producing pellets for big plants (industrial or thermo electrical plants), but not for civil uses (6 mm pellets).

There is only one enterprise that, until now, is trying to produce pellets from agricultural residues; this manufacturer has been started production only for 5 months, but it will probably **produce 12-15,000 tons/year of agri-pellets.**

4.3. Prices

Passing to examine the price, we must firstly do some preliminary considerations: we don’t know directly the pellets price for the years from 1995 to 1999. A survey conducted among the producers has not given a unique result: there are disparate opinions. While for some producers the price has increased, for others the price has been stable. However, if we consider the conditions prevailing in the Italian market, we can reasonably assume that the price has lightly increased, with a remarkable jump above all in the year 1999-2000. In the last two years the price has been stable, but can be easily foresee that there will be soon a further increase. This “jump” is due to the increasingly difficulties in finding the raw material from which the pellets is produced. In fact, in the last years there has been a “run” on wood waste. This is a consequence of the increasing importance that the biomass in general among the renewable energies, sawmills and wood residues in general are seen as a precious and costly resource. With the development of the pellets market, the request for wood residues from both industrial residues and forestry management is continuously rising, and so these continue to become an increasingly scarce resource. Moreover, there is the competition of the wood recyclers, which utilise the industrial residues to make panels and pallets. This competition has brought an increase in the price of raw materials, and probably will bring to further increases.

After these considerations, we can pass to quantify the price. In previous researches (CTI, PROBIO Program) it has been quantified for the years 2001-2002 in a range between 0.21 and 0.26 €/Kg. Bearing in mind the previous considerations, we can quantify the price for the period preceding the year 2000 in 0.15-0.20 €/Kg. In our research, for the year 2003, a in the **retail market** price in a range between **0.25 and 0.35 €/Kg** prevails, depending on

seasonal variations. There are, however, depths of 0.18 €/Kg and heights of 0.40 €/Kg. These extremes are expressive of a market not yet structured, that present differences at a regional level and, in the same region, among different producers.

For the wholesale market the price varies among 15 and 25 € per quintal.

Production Costs (raw material included)	0.07-0.08€/kg
Wholesale Price	0.11-0.15€/kg
Retail Price	0.21-0.26€/kg

Figure 11: Production Cost and Price for pellets production in 2001-2002 (Italy)

(Source: CTI, Biofuels National Program (PROBIO))

Considering only the pellets from agricultural residues, there is no "true" market for this kind of product. There is one producer that produces stoves fuelled at the same time with pellets AND maize; this producer also distributes the necessary pellets and grain. The use of maize and corn granulates must however be considered as an competitor to pellets.

It however must be noted that some pellets producers are studying in laboratory the utilisation of agricultural residues for pellets, above all residues from vines and tendrils.

4.4. Domestic pellets exploitation capacity

4.4.1. Heat and power applications

It is even more difficult to find information on the installed combustion capacity using agri-forest residues. GRTN (the national grid operator) has 55 active plants registered that are fuelled with waste and vegetable residues, and 22 projected plants. Unfortunately, the category definition is broad, and includes plants fuelled with biogas, chips and waste. In a more precise classification we find in the year 2000 6 plants fuelled with "cultivation and agri-industrial waste", and in the year 2001, 7 plants. During the calls with the pellets producers we have known that there are at least two co-generation plants fuelled with pellets, but the producers didn't reveal these plants.

On the Alpine arc there are many district heating plants, and their number is increasing every year. These plants are fuelled with chips and sawdust and use pellets only in occasional cases. District heating is more and more diffuse in Italy

Probably, the pellets is used in CHP and district heating big plants too, but it is difficult to verify because of this plants are generally classified as "biomass plants".

Year	Pellets sold (tons)	Price (Euro/Kg)
1990	-	-
1995	5,000	0.15-0.20
1996	≥10,000	
1997	-	
1998	≥50,000	
1999	≥70,000	
2000	-	-
2001	85-95,000	0.21-0.26
2002		
2003 (projected)	100-130,000	0.15-0.40

Figure 12 : Trends in wood pellet production and price (Italy)

In Italy, in 2001 there were 42 district-heating plants, against the 27 registered in 2000 (Source: AIRU 2001, Italian Association of Urban Heating). To these systems must be added 41 district-heating system of small dimensions **fuelled with wood biomass**, functioning in small Alpine communes in the North of Italy, above all in Lombardia, Piemonte and Trentino Alto Adige. These plants have an installed power of 55 MW. It must be pointed out that some dozen small biomass plants are actually in planning or manufacture.

The diffusion of pellets is more and more focused on very small plants for domestic or small-scale district-heating, above all in public buildings such as sporting centres, public schools and fairs. These small plants have boilers with an average power of 600-1000 kW, and consume in total a few hundred tonnes of pellets per year.

Considering that:

- In the last year, the amount of district-heated volume has grown by about 8.6 million m^3, (a growth of 7.4% with respect to the previous year);
- These increments are uniformly distributed across the whole grid;
- The major part of the projected district-heating plants are fuelled with biomass

We can reasonably assume that there is a huge potential for the increased use of pellets as fuel for district-heating.

	Year		Variation	
	2000	**2001**	**Absolute**	**%**
Number of functioning district heating systems	27	42	15	
Total heated volume	117,291,000m^3	125,936,000 m^3	8,645,000 m^3	7.4%

Figure 13 : District heating installations in 2000 & 2001 (Italy)

The below table shows the evolution of the Italian energy mix. The retreat from traditional fossil fuels such as coal, and the rapid adoption of biomass and waste as energy sources - is clear to see.

Sources of Primary Energy	**Tep**	**%**	**Tep**	**%**
Natural Gas	623 219	61	150 000	67
RSU	199 805	19	0	0
Coal	102 804	10	49 000	22
Oil	67 505	7	20 000	9
Industrial waste	13 511	1	1 000	0
Geothermal	9 552	1	3 000	1
Biomass	9 269	1	0	0
Total	1,025,665	100	223.000	100
Total Renewables	232.137	23	4.000	2

Figure 14 : Sources of Total Primary Energy Supply for urban heating in Italy

The table below shows the geographical distribution of this consumption. The “North-focus” is clearly evident from these figures. In particular, the importance of the Lombardy region is clear.

	Volumes	
Region	**Mm3**	**%**
Lombardia	54.3	43.1
Piemonte	31.9	25.3
Emilia Romagna	19.5	15.5
Veneto	10.0	8.0
Trentino A.A.	4.3	3.4
Liguria	2.5	2.0
Lazio	2.2	1.8
Toscana	0.9	0.7
Marche	0.4	0.3
Total	125.9	100.0

Figure 15 : Distribution of district heating in Italy

4.4.2. Equipment manufacturers

The utilisation of pellets for heating uses is still in its early days. The civil utilisation has experiencing a remarkable boom in the last 2-3 years, as confirmed by the growing number of retailers that sell pellets stoves and boilers. It must be underlined that the great majority of citizens don't know of the existence of this kind of heating equipments.

In Italy has been taken a census of 58 producers of pellets stoves and boilers; this datum is surely incomplete, and every day of research takes to discover new names of producers. In fact, as in the case of pellets producers, the Italian market is characterised by many small producers, with a limited range of action. These small manufacturers encounter many difficulties in commercialising their products; as stated before, pellets are not a well-known product in Italy, and so a small enterprise that pushes this product faces many difficulties.

There are only about five stove and boiler producers of large dimensions, distributed on across Italy. These producers have created specific product lines and, thanks to their commercial imaging, have been successful in publicising and selling their pellet equipment.

Once more, as in the case of pellets producers, many actors have recently joined the market, gambling on the future importance of pellets. However, these producers are often forced to leave the market due to the many barriers still faced.

4.5. Conclusions

Summarizing the data and the impressions collected during these first months of research, we can state that the Italian pellet market is experience an increasing penetration. This success is however restrained by the lack of a precise legislation to guide the development of the market.

The pellets production industry has enjoyed a constant increase in the last years, but it has now reached its first upper limit. This limit stems from the now exhaustive exploitation of waste from the furnishing industry. For further growth, new sources of raw material must be tapped. The levels of pellet produced have constantly increased. However, the pellets price has followed a similarly upward trend, albeit to a lesser extent. This trend is due primarily to the difficulties in finding the raw material that is no longer seen as a waste, but as an increasingly scarce resource. So, to continue producing pellets in an economically feasible way, the pellet industry must explore new possibilities. These possibilities must be found in new ways of collecting wood from forestry management and, above all, in producing pellets from agricultural residues. This kind of production involves many investments that requires a precise strategy, both at the national and the European level. The pellet industry requires precise standards about the characteristics of pellets and funds to stimulate technological research.

5. Spain

5.1. Objective, Methodology and Contents

5.1.1. Objective

This report consists of a market assessment on the current situation of biomass pellets in Spain, in consideration of their production, consumption and utilisation. It comprises summarised information on all the data that have been collected since the beginning of the Pellets For Europe project. Thus*, a general overview on the state of the art of pellets production and utilisation in Spain* will be provided both from wood and agricultural residues.

In addition however, the objective of this report is to *quantify and assess the fluctuations that biomass pellets production and utilisation have undergone* during the last years, as well as to analyse and evaluate the *trends that can be expected* in the sector for the future.

5.1.2. Methodology and Contents

Regarding *methodology*, the information contained in this document has been collected following the same steps and tasks that were used to elaborate the report for Deliverable 16 (see pages 4 – 5 of that report).

The present work comprises all the information that has been collected up to now about biomass pellets market in Spain, including data from Deliverable 16 and the information that has been received in the last weeks.

The report *aims to*:

- Summarise CARTIF´s knowledge on the production and utilisation of wood and agricultural pellets with energy purposes in Spain.
- Provide an assessment study on the current situation of the market.
- Consider biomass resources to assess the potential development of the market and the raw materials that could be destined to pellets production.
- Analyse the fluctuations that pellets production and utilisation have undergone in Spain and assess, according to the previous data, the expected trends.

5.2. Sources of wood and agri-residues

5.2.1. Raw material for pellets production

Information has been collected on residues produced in Spain from agricultural, forestry and industrial activities. Institutional stakeholders and representatives agree that there are not reliable estimations of biomass resources in Spain.

If we refer to the Spanish Plan to Promote Renewable Energy Sources (IDAE, 1999) [1], several estimations have been made. According to those energy forecasts, measures proposed in the Plan would allow to generate in 2010 the following energy resources, additionally to the current exploitation:

Forestry wastes:

- 450 000 toe/year in 150 000 hectares/year.

Agricultural wastes:

- 350 000 toe/year of woody agricultural wastes.
- 1 350 000 toe/year of herbaceous agricultural wastes.

Industrial wastes:

- 250 000 toe/year of forestry industries wastes.
- 250 000 toe/year of agricultural industries wastes.

Energy crops:

- 3 350 000 toe/year.

A remark must be added to these figures: the Plan forecasts on biomass development are not being fulfilled up to now.

Estimations obtained from IDAE (Institute for Energy Diversification and Saving) in 2000 show the energy that could be obtained from biomass wastes in Spain:

Forestry wastes:

- 1 373 000 toe/year of forestry wastes.

Agricultural wastes:

- 1 004 000 toe/year of woody agricultural wastes. The main woody crops in Spain are olive grove, vineyard and fruit trees.
- 7 866 000 toe/year of herbaceous agricultural wastes. The most usual herbaceous crops in Spain are wheat, barley, oat, rye, corn, rice, sunflower, rape and cotton.

Industrial wastes:

- 1 066 000 toe/year of forestry industries wastes both from 1st and 2nd processing installations.
- 309 000 toe/year of oil mill residues.

The market for energy crops is not significant in Spain so far.

Emphasis must be made in the low accuracy of these data, according to the information source. However, although quantities estimations are not completely reliable, they provide a gross idea of the current situation. Figure 16 shows the same data by regions.

REGION	Forestry residues	Agricultural residues			Forestry industries residues			Oil mill residues	TOTAL
		Herbaceous	Woody	Total	1st proc.	2nd proc.	Total		
Andalucía	124.380	1.152.960	266.740	1.419.700	63.850	53.270	117.120	245.868	1.907.868
Aragón	98.058	730.930	84.930	815.860	24.275	15.051	39.326	3.281	956.525
Asturias	34.238	2.180	2.470	4.650	21.965	8.219	30.184	0	69.072
Baleares	0	21.880	13.240	35.120	2.768	14.755	17.523	315	52.958
Canarias	0	2.030	3.020	5.050	7.905	14.558	22.463	0	27.613
Cantabria	25.823	1.830	0	1.830	4.873	5.050	9.923	0	37.576
Castilla la Mancha	113.156	1.188.480	145.510	1.333.990	29.797	27.328	57.125	21.615	1.625.886
Castilla y León	367.668	2.863.020	22.850	2.885.870	63.647	22.179	85.826	666	3.340.030
Cataluña	92.340	605.670	129.170	734.840	66.712	79.813	146.525	10.725	984.430
Comunidad Valenciana	54.851	97.490	145.160	242.650	56.923	85.058	121.981	7.016	426.498
Extremadura	134.338	380.510	64.790	445.300	4.981	5.346	10.327	15.791	605.756
Galicia	220.461	181.380	6.240	187.620	175.209	29.807	205.016	0	613.097
La Rioja	12.454	97.830	31.310	129.140	4.588	4.852	9.440	190	181.224
Madrid	12.991	101.100	7.410	108.510	4.630	33.870	38.500	1.345	161.346
Navarra	19.302	331.110	11.530	342.640	16.581	7.029	23.610	409	385.961
País Vasco	34.239	92.170	3.240	95.410	84.256	23.566	107.822	18	237.489
Región de Murcia	29.129	15.460	66.360	81.820	5.882	17.530	23.412	1.293	135.654
SPAIN	**1.373.426**	**7.866.030**	**1.003.970**	**8.870.000**	**638.842**	**427.281**	**1.066.123**	**308.532**	**11.618.081**

Figure 16 : Annual energy that could be obtained from forestry, agricultural and industrial wastes, by regions (toe/year) (Italy)

(Source: Institute for Energy Diversification and Saving, 2000)

In addition, the following comments can be made:

Regarding herbaceous wastes, the most frequent crops in Spain are barley, wheat and corn, and so most residues come from these crops residues. Castilla y León, Castilla la Mancha and Andalucía are the regions with the highest production of crops, and consequently of residues.

With respect to woody crops, Andalucía is the main olive producer and so most olive wastes come from there; a considerable amount of wine production is centred in Castilla la Mancha and the larger fruit trees surface is in Comunidad Valenciana. Wastes distribution follows a similar tendency. Globally, Castilla la Mancha and Comunidad Valenciana are the regions with the highest residues production from woody crops.

If we consider industrial wastes, Andalucía, Castilla y León, Cataluña, Comunidad Valenciana, Galicia and País Vasco are the regions with more quantities of wood industrial residues that could be used with energy purposes; bark, sawdust, shavings, dust and wood pieces wastes are the most usual ones.

Globally, Castilla y León, Andalucía and Castilla la Mancha are the regions with more wastes potential to be used for producing energy.

It has to be pointed out that quantities produced vary a lot from one year to another. As an example, Figure 17 shows the strong variations of wheat yields and production between 1998 and 2003.

		1998	1999	2000	2001	2002	2003
HARD WHEAT	National surface (ha)	625 035	817 929	867 984	882 834	924 714	908 173
	National production (ton)	1 290 300	658 100	1 916 800	1 755 900	2 021 400	2 170 800
	National yield (ton/ha)	2.06	0.80	2.21	1.99	2.19	2.39
SOFT WHEAT	National surface (ha)	1.249.902	1.604.526	1.501.812	1.319.799	1.476.416	1.365.827
	National production (ton)	4 056 700	4 425 700	5 416 300	3 182 000	4 478 600	4 251 500
	National yield (ton/ha)	3.25	2.76	3.61	2.41	3.03	3.11

Figure 17 : Wheat production in Spain from 1998 to 2003

Reasons for these fluctuations are basically climate, pests and governmental subsidies.

We have also searched for information on wastes prices. In general, it can be said that prices are very variable depending on the nature of the residues, their availability in a certain area, the existence of different applications competing for the raw material, the specific characteristics of the region, the month of the year and particular circumstances that sometimes appear, as the crops yields of each year (that depend on climate). Data obtained show the referred variability, but it must be said that data for comparison have not been found in every region of the national territory and that this information comes mostly from Castilla y León region.

Cost of *forestry* residues: from below 20 to 120 €/tonne.

Cost of *wood industries* residues: from 6 to 48 €/tonne.

Cost of *agricultural* residues: from 12 to 48 €/ton. A study obtained from COAG (Spanish agricultural association) determines the price of cereal straw in a certain area of Burgos (Castilla y León), with the purpose of burning it in a hypothetical biomass plant. According to this report, the price of straw (including production, packing and transportation costs to the plant) would be 36 €/ton. Another study on barley straw carried out in Menorca (Baleares) by CCEA (Agricultural centre) establishes this price in 108 euro/ton, which shows the high variability of the price that has been already mentioned.

Cost of *energy crops*: from 24 to 48 €/ton.

Looking at the current utilisation of biomass wastes:

Forestry wastes are collected for fire and pests prevention, as well as for environmental reasons. Collection is organised by each region and/or municipality, so there are differences on the wastes management and treatment in each area, as well as in the collection frequency. Costs of this collection are high and depend on the forests dispersion, type of trees, ground slopes, etc.

Forestry wastes are usually sent for disposal without any valorisation or left on the ground for soil fertilising. Sometimes, they are used in small stoves and boilers of the domestic sector for heating. In a few cases they are sent to a a biomass plant nearby (for example, district heating of Cuéllar in Castilla y León or electricity production in Allariz, in Galicia).

***Agricultural wastes* are used in a wide range of applications:**

Herbaceous wastes (from cereals and vegetables) are mostly straw and stubble. They are mostly destined to livestock food and bed. It was usual to burn them directly in the fields, but this has been diminished or almost eliminated by governmental measures. Other uses are: certain kind of paper production, chemicals extraction, as a component in boards manufacturing, as isolating material, as construction material, for mushrooms cultivation, for manure and compost production, etc. [3]

Woody wastes (from olive, vine and fruit production) are usually burned in the field or used for meat cooking in barbecues. Another application is their decomposition for soil fertilising.

Agricultural industries wastes (rice, beer, wheat, coffee, oil, textile and other industries) are mainly used as fuel, for compost production, for mushrooms production and for animal food and bed.

Wood industries wastes are usually sent to boards manufacturing industries. Other factories use their own wood wastes for heating or send them to other external agents for residues management (boards manufacturers are also authorised residues managing companies for these kind of wastes).

All these applications compete with pellets production in the raw material required.

Referring to the raw material utilised at the moment for pellets production, pellets produced in Spain with energy purposes use mainly wood wastes as raw material. In general, briquettes and pellets installations use *ligno-cellulosic residues generated in industrial processes*, with the objective of solving the problem of residues accumulation. Approximately 45 % of the raw material comes from wood industries (for example, sawmills); 45 % comes from wood manufacturing industries (furniture factories – 57 %, doors manufacturers – 26 %, parquet manufacturers – 11 %, etc.) and 10 % comes from other raw materials, such as forestry residues, textile industries residues, etc. Raw material is mostly used as sawdust or splinters because it drastically reduces physical transformation and hydro-thermal treatment costs.

Agricultural wastes are used to produce pellets too. There are several factories in Spain that manufacture pellets from agricultural residues for animal food, for example in sugar

refineries or companies dedicated to animal food production. Eventually these pellets can be used as fuel; for example, there is an industry situated in Navarra that manufactures straw pellets for animal food, but part of its production is commercialised as fuel when there are agricultural surpluses.

Forestry residues have not been used for pellets production up to now, except for experiments carried out by research institutions [2] or as additional supply in installations that use mainly other raw materials.

No installations have been found using other types of wastes as raw material.

5.3. Pellets production

In Spain, the market of compact energy products is mainly constituted by briquettes. Sometimes the production has been insufficient to cover the national demand because most of the 20 briquettes installations existing in Spain were designed to transform wood industry wastes, which are now being utilised for other applications. It is necessary to point out, too, that Spain is a briquette exporter thanks to its low prices in relation to international markets. As an approximate value, in Spain 50.000 – 60.000 ton/year of briquettes and pellets are produced (year 2001).

If we refer to *Spanish pellets plants*, nowadays there are two pellets plants in A Coruña (Galicia) and Cuenca (Castilla la Mancha), that are not working. There are also two operative pellets plants in Galicia and Toledo (Castilla la Mancha), but the last one belongs to VAPORMATRA, whose central office is in Galicia. Therefore, the sector of pellets production as fuels is centred in the region of Galicia. Both manufacture pellets from wood industries wastes (sawdust and shavings), with small amounts of forestry wastes. The first one has a production capacity of 15.000 – 20.000 ton/year and the second one, of 6.000 ton/year. According to other information sources, their real production could be significantly lower than their production capacity; it has been impossible to contrast and confirm this information.

On the other hand, there is another industry situated in Navarra that manufactures straw pellets for animal food, but part of its production is commercialised as fuel when there are agricultural surpluses. Nowadays they are trying to produce pellets from forestry and industrial wastes. They were reluctant to collaborate and have not provided any information or figures about the company.

Contacts have also been established with two future pellets producers. One of them is a briquettes manufacturer that wants to start pellets production this year. According to information from the company, their pellets production would be significantly higher than current. Raw material for pellets production would be oak sawdust.

The other future pellets producer is studying the possibility of using forestry wastes, agricultural wastes and energy crops as raw material. The plant capacity production would be 6.000 ton/year.

We have known on the existence of other similar initiatives, but we have not got information from them.

There are also several other industries that produce pellets from agricultural wastes, but their final use is animal food and they have not been considered in this study, although their products (perhaps a bit modified) could be used with energy purposes if animal food or pellets markets changed.

Raw material for pellets production comes from local and national markets, although a certain amount is imported from foreign countries.

With regard to *technologies for pellets production*, there is a high dependence on foreign technology for pelletisation. In Spain there are not national manufacturers of pelletisers. Most factories that produce pellets with energy purposes affirm that their equipment was bought to Amandus Kahl Iberica, which is the most established manufacturer in the sector. Equipment supplied are flat die pelletisers; no additives are used. Pellets diameter is 6 mm in most cases.

In Spain there are not any regulations for pellets manufacturing. According to our investigation results, none foreign *standard specifications* are being used for pellets production and distribution in Spain.

Although much of the production is *sold* in the national market, a significant amount of biomass pellets is destined to other European countries, mainly Italy. France and Germany are also importers of Spanish biomass pellets.

Regarding their *economic data*, pellets producers are reluctant to provide any economic information about their companies for reasons of confidentiality.

Distributors of biomass pellets are usually companies that also sell other solid fuels, as splinters or coal.

5.4. Prices and consumption

Approximately 30.000 toe/year of compact energy products are being *consumed* in Spain. As it has already been said, sometimes the production has been insufficient to cover the national demand because of the lack of raw material, that competes with other applications, such as boards manufacturing. Sometimes pellets have been imported from Canada and some European countries.

With respect to *pellets use*, most production is destined to domestic pellets stoves with an average consumption of 3 ton/year. Other consumers are residents' associations, which use pellets in their boilers.

One of the pellets producers is also a pellet stoves producer, and so its whole pellets production is destined to the stoves he has previously sold. He is the most important producer nowadays in Spain.

Regarding figures, the amount of pellets consumed in Spain with energy purposes is very difficult to determine, because most consumers buy small quantities and they are dispersed all over the geography. Accurate figures on production, importation and exportation are not either available, so consumption estimations cannot be done.

Pellets price for consumers have been got from energy agencies information. According to them, pellets made from forestry residues cost from 72 to 180 euro/ton, while pellets made from agricultural residues cost more or less 72 euro/ton (2002). Pellets price depends highly on the price of the raw material, the month of the year, the area and the demand.

Considering that coal used for domestic heating has a price of 120 – 150 euro/ton and that pellets cost is below 120 euro/ton, it can be said that pellets are profitable for users and that installations for pellets combustion can be written off in less than 5 years (see Figure 18 for comparison with different fuels).

FUEL	LHV (kcal/kg)	Price (euro/ton)	Price (euro cents/therm)[2]
Fuel oil I (dry basis)	9.700	90 – 170	0,90 – 1,74
Fuel oil II	9.500	70 – 130	0,66 – 1,32
Fuel oil I	9.500	80 – 110	0,78 – 1,20
Gasoil C	10.000	250 – 430	2,52 – 4,33
Anthracite	7.300	120 – 140	1,62 – 1,92
Firewood	2.500 – 3.500	30 – 90	1,20 – 2,52
Briquettes	4.300	60 – 180	1,38 – 4,81
Pellets	4.440	100	2,28

Figure 18 : Various fuel costs in Spain

With relation to *equipment for pellets combustion*, national technology does not exist. However, there is a low but increasingly number of distributors of foreign equipment. In addition, there are numerous national and foreign manufacturers, distributors and installers of biomass boilers, in which biomass pellets could be burnt. Although most of them have not burnt pellets in their equipment yet, some have made adaptations to burn biomass and affirm that it would not be difficult to adapt them to pellets.

No CHP or district heating *plants* have been found *fuelled by pellets*, although there are several installations fed with biomass that produce energy.

5.5. Trends and future prospect in Spain

Globally, biomass wastes utilisation with energy purposes in Spain is not an expanding market. Compact energy products (briquettes and pellets) are the unique with a slight quantitative and sustained increase in the last years. In the last decade a significant increase in densified biomass fuels for domestic use has taken place. However, industrial

[2] A coefficient should be applied, depending on the net yield: 0,8 – 0,9 for pellets; 0,6 – 0,7 for coal; over 0,5 – 0,7 for firewood and above 0,9 for oil products

consumption has not followed this tendency due to difficulties with the regular supply and prices of raw material.

Installations with an output higher than 2.000 kg/h have gone out of business due to the difficulties to have a guaranteed supply of raw material, both in quantity and quality. Wastes from the first and secondary wood processing industries are increasingly more and more unavailable, since they are used and recycled in the factories where they are produced, or commercialised in other sectors, as in boards making. These residues, that represent from 15 to 30 % of the manufactured wood and have an enormous energy potential, are more and more scarce and expensive. Therefore, the dependence on external biomass sources is the most serious problem in this type of factories and as a consequence, market has got stabilised.

For this reason, to increase the production of this clean fuel, that may replace coal and firewood, it is necessary to use other raw materials, such as forestry and agricultural residues, which have a very important energy potential (5 MWh/ton of dried material). The introduction of pellets in the solid fuels market has good prospects and semi – industrial installations are starting to use other raw materials (for example, energy crops, as it has already been said).

No figures have been found on pellets production by years, neither on raw material and pellets prices fluctuations. Provided the scarce information available, it is impossible to quantify future production / consumption or to estimate how many of biomass wastes could be destined to pellets production, provided that we do not know exactly even the amount produced at the moment.

Production and consumption of densified biomass fuels have increased during the 90's in Spain. According to our investigations they are going to increase more because several future producers have been identified and different raw materials are starting to appear in the market of compact energy products. The development of knowledge on densified biomass fuels is, however, very local and experimental, which frequently leads to a wasteful use of resources, suboptimal technological solutions and, generally, poor profitability in the absence of governmental subsidies.

Nowadays a good technology development has been reached in certain countries, which allows to tackle the first industrial stage in compacting processes. Laboratory research is focused on the design of new blends that allow to use other types of residual products. However, several aspects need to be improved for a real introduction of pellets in the Spanish fuels market [2]:

- Processes optimisation with the objective of reduction of production costs, that are the limiting factor for the pellets market penetration. Increase in efficiency to diminish costs, too.
- New and more versatile manufacturing processes.
- Development of new materials with higher strength, to reduce abrasion and attrition.
- Development of new equipment, able to be adjusted to different types of residues and to obtain densified products of different characteristics (density, diameter, etc.).

- Improvement of feeding systems to avoid blocking and facilitate continuous operation.
- Increase in the processes automation to reduce operation costs.
- Development of more efficient combustion and gasification systems to obtain higher yields that justify the higher price of the fuel, compared to other solid biofuels.

Two parallel research lines can be distinguished:

- High quality densified products without exceeding a certain price.
- Medium quality densified products for the industry, with minimum prices.

5.6. Conclusions

Spanish biomass pellet market with energy purposes is nowadays small. This has made difficult data collection because institutional entities have got little information on it and companies involved in the market do not want to provide information to avoid giving information to competitors.

High quantities of biomass residues (agricultural, forestry and industrial ones) are produced in Spain and could be used for energy production, for example, for biomass pellets production. The Plan to Promote Renewable Energy Sources in Spain pretends to increase significantly those quantities in the horizon of year 2010. No reliable estimations have been made on wastes production and consumption. In addition, the market of biomass wastes is not regulated and many applications compete for certain raw materials while others exceed. Consequently, there is low reliability on both quantities and prices of resources, as well as a strong variability on wastes prices.

The biomass pellets market has still a low development due to several barriers that will be analysed in further Deliverables of the project. Some of them have been pointed out here, as the competition for wood industrial wastes with board manufacturing.

However, it can be said that it is now in a changing stage because, in addition to the few well – established companies that produce and commercialise pellets, our investigations have succeed in finding several new market actors interested in producing pellets, distributing pellet stoves or adapting their equipment to pellets. Research centres and universities, as well as national and local energy agencies are also interested in the subject, and are trying to overcome current barriers from their different points of view. Moreover, raw material diversification is starting to be considered, as the present report has showed, too.

Finally, further development of this market can be expected, due to other European countries market development and the interest of the agents involved.

6. Greece

6.1. Sources of wood and agri-residues

Agriculture is considered an important sector of the Greek economy accounting for 20% of the total employment and 6% of GDP (Ministry of Agriculture, 2003). From a total of 13.2 million ha of the total land area of Greece, the area devoted to agriculture constitutes 9.2 million ha from which 5.2 million ha are pastureland, 3.9 ha are cultivated with various crops and about 0.5 million ha are left fallow every year (NNS a).

The sector suffers from structural weaknesses that are reflected in poor international competitiveness. Structural impediments to enhance productivity are mostly due to the large number of small inefficient farms, with the average farm size being just 25% of the EU average.

Agriculture has also become very intensive with a heavy use of fertilisers and pesticides, which has led to a levelling of yields, a declining quality of farmland, and signs of environmental degradation. In addition, easy access to water resources (through, for instance, unlicensed artesian wells) and low prices has encouraged wasting of water resources. As agriculture accounts for 85% of the country's water consumption, water shortages are looming.

6.1.1. Importance of wood – solid biofuels as a source of energy [3]

The total biomass contribution, as primary energy, is presently estimated at 1 Mtoe/year, and can considered as, more-or-less, stable in the short run, as the two opposing major tendencies balance each other:

- Negative trend: gradual decrease in the use of traditional bioenergy (fuelwood)
- Positive trend: slow growth of new bioenergy applications (agro-industrial residues)

With respect to the form of biofuels used in Greece, we should note that more than 95% of the above defined contribution is in the form of solid biofuels, which are mostly (by more than 90%) used for energy production without any type of refining or upgrading. The only other type of biofuel with some use worth mentioning is biogas.

In contrast to what is happening in most European countries, within the present bioenergy use in Greece, forest-derived woody biomass does not represent the dominant type of solid biofuel. As we can easily see in the following approximate categorization, Greek bioenergy is mainly based on agricultural – derived sources (% of total primary bioenergy contribution):

[3] *BIOHEAT, 2003. EVA, Final Report, Altener 4.1030/Z/00-163-2000, Vienna.*

TYPE	%	ktoe/year	trend
Fuelwood from forests	40	400	-
Fuelwood from tree crops	30	300	+
Agro – industrial residues	20	200	++
Charcoal, forest derived	3	30	--
Charcoal, agriculture derived	3	30	--
Other (biogas etc)	4	40	+
TOTALS	**100**	**1,000**	**+/-**

Figure 19 : Biomass used in Greece

(Source: NTUA, Dept of Chemical Engineering,1998)

The main type of bioenergy use in Greece is, still, the traditional, rural one, i.e., for space heating in farm-houses, equivalent to 2-3 kW thermal per house, requiring 2-3 t of solid biomass/year (fresh amounts of forest or tree crop derived wood). This form is in some kind of long range, slow decline, following corresponding socio-economic changes in rural areas.

This is followed in importance by the use of agro-industrial residues - such as olive kernels, cotton-gin wastes, fruit processing wastes, etc – mainly for process heat generation at agro and cottage industries, based on the utilization of their own wastes and residues. On the other hand, the option of bioelectricity is only starting to be considered by Greek companies.

The main obstacles identified for the deployment of the use of solid biofuels in Greece are the following:

- Resource: - Availability, seasonable patterns of generation
  - Collection, storage and handling aspects
- Technical: - Maturity of certain conversion technologies (e.g.: gasification)
  - Role of inorganic constituents (e.g.: ash malting)
- Economic: - High initial capital required
  - High interest rates
  - Lack of venture-risk-capital firms

6.1.2. Current agricultural biomass resources in Greece

Agricultural crop residues [4,5]

In Greece, the total agricultural land is about 3.9 million ha, of which 60% is arable land, 25% is cultivated with trees and vines, 3% is garden area and 12% is fallow land (NSS a).

The quantities of residues from the annual and perennial crops cultivated in Greece, in tonnes of dry matter per year, were estimated using data from the Annual Agricultural Statistics, on the cultivated areas and the quantities of the main product produced per year for each crop and for the years 1996 – 1998 (NSS a). Additionally, coefficients that indicate the ratio of residue quantity to product yield and the moisture content of each type of residue were derived from literature (Apostolakis et al., 1987) and are presented in Table 2.

In a further step, the theoretically available quantities were assessed taking into account the percentages already used. From the total agricultural residues produced in Greece, a part is already exploited and used in several energy and non-energy markets. Cereal straw is used for various purposes such as animal feeding and animal bedding. There is also a greenhouse in northern Greece using straw for heat production (250 MWh/year, CRES, 2002). Therefore it has been assumed that only 15% is available for bioenergy applications (Voivontas, et al., 2001). In the case of rice straw, cotton and corn stalks and corncobs although no alternative markets have been reported, the availability percentage was set to 60% due to difficulties in harvesting and handling. Olive prunings (especially the large stems) are used in stoves and fireplaces for residential heating and their availability was set to 50%, while prunings from vines and other types of trees are not preferred for this purpose and it was assumed that 80% are available for bioenergy applications (Alexopoulou et al., 1999).

Residue	Product / Residue ratio	Moisture (%)	Higher heating value (MJ/kg)	Cultivated area (ha)	Available quantities (dry t/year)	%
Durum wheat straw	1.00	15	17.9	245,019	80,415	2.1
Soft wheat straw	1.00	15	17.9	612,047	184,378	4.8
Rice straw	1.00	25	16.7	27,982	94,320	2.5
Barley straw	1.24	15	17.5	144,884	35,741	0.9
Oats straw	1.27	15	17.4	43,853	8,307	0.2
Corn cobs	3.75	50	18.4	213,181	165,694	4.3
Corn stalks	1.42	60	18.5		350,059	9.2

[4] *Mardikis, et al., 2003.*

[5] *EUBIONET Biomass survey in Europe, Country report of Greece, CRES 2003.*

Sunflower straw	0.50	40	14.2	26,818	28,603	0.7
Cotton stalks	0.50	45	18.2	412,727	877,809	22.9
Sugar beet leaves	2.51	75	14.6	42,585	123,084	3.2
Tobacco stems	0.91	85	16.1	67,070	14,260	0.4
Vineyard prunings	1.20	40	18.3	133,408	364,471	9.5
Olive prunings	0.98	35	18.1	749,522	881,314	23.0
Peach prunings	2.51	40	19.4	45,993	121,383	3.2
Pear prunings	1.26	40	18.0	4,213	30,727	0.8
Apple prunings	1.20	40	17.8	14,874	139,080	3.6
Apricot prunings	2.84	40	19.3	5,047	7,864	0.2
Lemon prunings	2.22	40	17.6	11,917	39,207	1.0
Orange prunings	2.90	40	17.6	40,050	152,404	4.0
Cherry prunings	1.20	40	19.1	8,613	19,404	0.5
Tangerine prunings	1.55	40	17.6	6,137	22,864	0.6
Almond prunings	0.28	40	18.4	23,613	83,921	2.3
Total				**2,789,553**	**3,825,309**	**100**

Figure 20 : Characteristics of crop residues studied for Greece (1996-98)

Based on the above it was estimated that approximately 3.8 million dry tonnes of field crop and arboricultural residues are theoretically available for energy production (Table 2) with a total energy potential of 69 PJ/year (Mardikis, et al., 2003).

The data for agricultural residues presented in the previous report (Table 6), “Assessment report for Greece” deliverable 16 and also presented here as Table 3, depict the theoretically available quantities of the main agricultural residues, in the order of about 7,000 tons/year and also refer to year 1999 (Mardikis, et al., 2003), whereas the reported values above refer to an average of 1996-98.

Region	Type of residue	Current utilisation of residues	Output (tons/year)	Cost of residue (if applicable)	Proportion currently exploited for pellets
Sterea Ellas	C [1]	[2]	1,002,610	[3]	0
Peloponnisos	C [1]	[2]	1,219,340	[3]	0
Ionian Islands	C [1]	[2]	145,981	[3]	0
Epiros	C [1]	[2]	224,664	[3]	0
Thessaly	C [1]	[2]	1,221,106	[3]	0
Macedonia	C [1]	[2]	1,974,225	[3]	0
Thrace	C [1]	[2]	508,722	[3]	0
Aegean Islands	C [1]	[2]	143,253	[3]	0
Crete	C [1]	[2]	516,694	[3]	0
Total agricultural			**6,956,595**		

Figure 21 : Main Agricultural Residues (1999)

[1] The agricultural residues under consideration are cereal straw, maize cobs and stalks, cotton stalks, olive tree and other fruit tree prunings. Data refer to 1999.

[2] Cereal straw is used mainly for animal feeding. Olive tree and other fruit tree prunings are used as wood fuel for residential heating

[3] The average price of cereal straw for animal feeding is ~60 Euro/ton. The average price of olive tree prunings (sold as wood fuel) is ~59 Euro/ton.

Residue type	Year	Output (tons/year)	Proportion exploited as pellets
Agricultural	1990	5,321,576	0
Agricultural	1995	5,862,369	0
Agricultural	1999	6,956,595	0

Figure 22 : Main Agricultural Residues in Greece from 1990 to1999

The following figure represents the geographical cover of the available agricultural residues in the prefectures of Greece and the highest production is shown in the Prefecture of Larissa with 315,000 dry tonnes/year and of Fthiotida with about 215,000 dry tonnes/year. In both areas the cotton stalks represent more than 60% of the total residue

potential (Nikolaou, et al., 2003). In this study the residues produced during the cultivation of food and fiber crops in Greece have been analyzed in terms of quantities, energy potential and spatial distribution, in an attempt to identify the most promising biomass feedstocks for energy production and the most promising regions for this kind of applications.

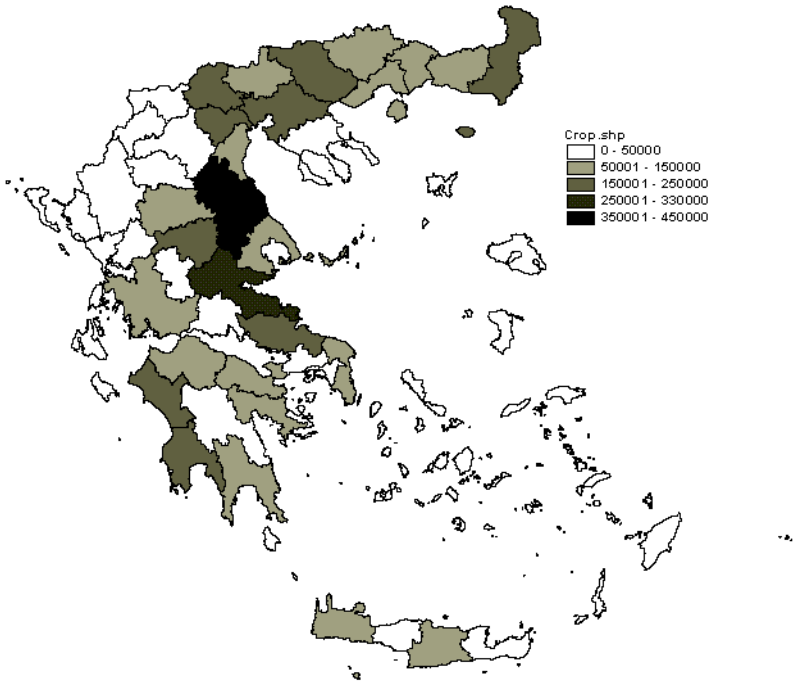


Figure 23 : Geographic distribution of the available quantities of agricultural residues in Greece.

Nowadays, the main volume of the aforementioned field crop residues are either ploughed back into the soil or burned in the fields. Although there are sufficient quantities of residues in the country, certain parameters should be taken into account before making a strategy for their energy exploitation.

- Small farming size that increases harvesting and transportation costs.
- Environmental risks caused by the removal of the residues from the field such as erosion in sloping areas and nutrient removal in low fertility areas, etc.
- Opportunity cost of the residue (e.g. cereals straw has already a market price as it is sold for animal feeding purposes).
- Lack of commercial harvesting machinery for certain residue types such as cotton residues.

Agro-industrial residues

Some typical agro-industries in Greece are: rice industries, cotton-ginning factories, corn industries, fruit industries, wine factories, seed oil industries, olive industries, olive oil and olive kernel factories.

The evaluation of the quantities and geographical distribution of this category of residues is complicated because of the different processing technologies, size and location of the processing plants and the characteristics of the final products (Blassi et al., 1997). Furthermore, there is no official data on the production of agro-industrial products at a regional level in Greece that could facilitate the estimation of the produced residues. Therefore, it is necessary to follow different methodologies, according to the availability of data for each type of residue.

In the case of rice mill residues, rice husk was estimated as a percentage of the harvested rice for which there are available data at a regional level. It is reported in literature and has been confirmed by the engineers in the rice mills that rice husk is approximately 20% of the processed rice, with average moisture content of 10% (CRES, 1996). The same assumption was made for cotton, since all of the harvested cotton is sold and processed in the cotton ginning factories. It has been reported that cotton-ginning residues are 10% of the processed cotton, with average moisture content of 17% (CRES, 1996). In the case of nutshells, the available data on the production of almond, walnut and hazelnut shells are only at a national level (NSS b) and these data were used to estimate the quantities of the produced hulls. The average shell/kernel ratios used were 1.2 for almond shells, 1 for walnut shells and 0.8 for hazelnut shells (Pontikis, 1987).

There are no available data concerning the annual production of fruit canneries. However, it has been reported that the total installed capacity at a national level is 200 000 tones/year for peach canneries and according to literature (CRES, 1996) peach kernels is 4.5% of the total fruit. Finally, the produced quantities of olive kernel wood were estimated based on the annual regional production of olive oil producing varieties, and the assumption that olive kernel is 23% of the olive fruit.

It was estimated that 593,742 dry tons of the above agro-industrial residues are produced in Greece (Table 5), with a total energy potential of 10 PJ/year (Mardikis et al., 2003).

Industry	Residue	Residue / Product ratio	Moisture (%)	Production (dry tons/year)
Rice mills	Rice husk	0.16	10	**30 311**
Cotton ginning factories	Cotton ginning residues	0.1	13	**132 079**
Peach canneries	Peach kernel	0.04	20	**6 400**
Olive kernel factories	Olive kernel wood	0.21	30	**423 110**
Peeling plant	Walnut shells	1.5	8	**119**
Peeling plant	Almond shells	0.95	5	**1 328**
Peeling plant	Hazelnut shells	1.07	5	**395**
Total				**593 742**

Figure 24 : Characteristics of industry residues studied for Greece

According to the RES Statistics for 2000 in Greece (CRES, 2002), several cotton ginning factories use their residues to produce the heat required for cotton drying and space heating of their facilities. The total heat energy produced has been estimated to be 0.4 PJ/year (CRES, 2002). Most of the olive kernel wood produced is used for greenhouse heating, space heating, etc., the total heat energy produced being 8.3 PJ/year. Fruit kernels and nutshells are also used for greenhouse and residential heating (0.01 PJ/year). Rice husk is used as a fuel for process heat in the rice mills (0.09 PJ) and for power production in one factory (0.44 MWe installed capacity).

6.1.3. Forest biomass resources

Greece, located at the southern end of the Balkan peninsula, is mostly hilly or mountainous and dry and rocky country. The forested area is only about 19.0% of the territory and the main owner is the state.

Forest management is characterised as especially difficult, since the wooded areas are sited in mountainous or remote regions with adverse pedoclimatic conditions, such as poor and thin soil as well as drought. Forest's condition is not satisfactory in terms of density, quantity and quality of the growing stock, due mainly to human impact of the past such as fires, grazing, land clearings, illegal fellings as well as lack of systematic silvicultural treatment.

The total forest area (industrial forests), of about 2.5 million ha, consist of 1 million ha coniferous species and 1.5 million ha broadleaved species. The high elevation conifers consist of black pine (*Pinus nigra*), scotch pine (*P. silvestris*) and fir (*Abies borissi regis*), while the Mediterranean zone conifers managed for pine resin and recreation functions consist of haleppo pine (*Pinus halepensis*) and calabria pine (*P. brutia*). The broadleaved species compose forests of beech (*Fagus silvatica*), oaks (*Quercus pubescens*, *Q. conferta*, *Q. sessiliflora*, *Q. cerris* etc.) and chestnut (*Castanea vesca*) as well as shrublands of evergreen hardwoods (the so-called maquis).

The major portion of forests is composed of sub-selection and selection stands while the remaining of even-aged stands. The structure appears as one-storied, two-storied and multi-storied. Forests managed as coppice totally consist of even-aged stands. The length of rotation of these coppice forests is 25-35 years, depending on the site, the climatic zone, and the species growing on the particular site. The main products of this type of forest are fuel wood and charcoal.

The mean growing stock of the Greek forests of about 45.2 m^3/ha compared to the mean growing stock of other European countries, is considered as relatively low. This figure does not indicate the real state of Greek forests, because there are many forest complexes which are well-organized and managed for a long time which support stands with a mean growing stock, ranging from 350 to 400 m^3/ha. The mean growing stock has decreased significantly because a high percentage of forests are coppice or over-thinned due mainly to human actions of the past, as mentioned above.

Region	Category a Fuelwood available to the market[1]	Category a Fuelwood currently used in rural domestic sector[2]	Category a Forestry residues[3]
Sterea Ellas	51,950	39,200	8,700
Peloponnisos	26,150	47,700	7,500
Ionian Islands	0	0	0
Epirus	38,850	119,800	7,000
Thessaly	62,600	75,350	10,800
Macedonia	465,250	294,850	55,000
Thrace	53,300	22,500	5,650
Aegean	1,400	100	1,550
Crete	0	4,050	100
TOTAL WOOD	699,500	603,550	96,300

	Output (tons/year) 1+3	Proportion exploited
WOOD 1992[4]	816,900	-
WOOD 1995[4]	654,950	-
WOOD 2001[4]	795,800	-

***Figure 25 : Fuel wood production in Greece for 2001* in tonnes (moisture content ~ 35%)**

(*Source: Ministry of Agriculture. General Secretariat of Forests and Natural Environment, Annual production data for 2001.)*

[1] These amounts are available in the market and are totally consumed in the domestic sector.

[2] These amounts are strictly available to rural population for covering domestic needs.

[3] These amounts are roughly estimated and are referred to residual biomass, which arises during logging operations (in the form of bark and branches).

[4] Refer to wood available in the market, i.e. the proportion of fuelwood that is available in the market and logging residues (i.e. 1+3).

6.1.4. Wood process residues from industrial uses (questionnaire category b)

Sawmills and plymills are the main wood processing industries, which generate the major proportion of residues. The average wood residues production as a proportion of raw material for both industries ranges between 30% and 50%. The amount of these residues has never been monitored accurately in Greece. It is estimated that about 80,000 tons of wood residues are available in country level for pellets or energy production by the

sawmills themselves, since only half of the totally produced find a market in composite boards, as raw material (Petinarakis J, 1993).

6.1.5. Barriers to fuelwood exploitation in Greece

The General Secretariat of Forests and Natural Environment of the Ministry of Agriculture is responsible for managing state forests, while non-state forests are governed by various bodies. Management is carried out through 10-year management plans, drawn up according specifications issued in 1953 and modified in 1965. New specifications are under approval, which stress the principles of sustainability, conservation of biodiversity and multiple-functional management of forests.

The main aims of national forest policy are the protection of forests and forest lands, the enrichment and improvement of growing stock, the increase of forest production, in terms of industrial wood, the enlargement of forest cover by reforestation, the augmentation of production of other goods and availability of other services deriving from the forests as well as the improvement of socio-economic conditions of the rural population. The main factors determining the targets of forest policy in Greece are the fulfilment of round wood production and fulfilment of services coming from the forest.

Greece has a rather small forest sector and a large share of its wood production is used as fuel. The wood of large dimensions is no more than fifty to sixty percent of the total volume harvested from forests producing such wood. The rest is wood of small dimensions, tops, branches and wood of low quality. While hardwoods are used mainly for energy purposes, the softwoods are processed into sawn wood and particleboard. The country imports all types of forest products, especially sawn wood and paper products.

Concluding, the main forms of energy wood produced in the Greek forests are fuel wood as well as logging residues. Other residues derived from early thinnings as well as from clearing operations for the reduction of fire risk, are not produced at all, since such operations are not or are poorly executed at present due to the lack of state financing.

Split and round fuel wood production is continuously declining from early 50's up today, being about 1.2-1.4 million tons nowadays, due to the expanded use of conventional fuels and the drastic concentration of the population to large centres. The production of fuel wood has been traditionally considered as one of the forest policy targets since this product has both commercial and social value. The major part of fuel wood produced (45-50%) is freely collected by the people living nearby the forests to cover their domestic energy needs (for cooking and space heating).

Concerning logging residues, in forestry practice large amounts arise during the harvesting operations (in the form of bark, tops, branches, leaves and needles) and are left behind in the forest terrain. The potential of logging residues in Greece is roughly estimated at 1.7 million tons (including stumps and roots), but only a part of them could be utilised for energy purposes after the introduction of modern harvesting technology.

Both the state forest managers and the particleboard industry have encouraged removal of logging residues for many reasons such as:

- providing raw material the particleboard industry,
- avoiding accumulation of biomass on the forest floor and reducing forest fire risk,
- making room for reforesting and facilitating access during forest operations, as well as
- ensuring the forest health by avoiding fungi and insect attacks.

The existence of steep slopes, the lack of mechanisation in harvesting operations (horses and mules are the standard form of power used to skid logs from the stump to the forest road) and the inefficient legal framework that regulates the system of forest exploitation through forest co-operatives, are the main reasons for not utilising forest residues.

6.1.6. Assessment of future trends

The agricultural sector in Greece – main structures and peculiarities

Despite the favourable climatic conditions prevailing in the area, Greek agriculture presents a slow development and modernization rate mainly due to certain peculiarities which determine its steps forward. Small size of farming land decreasing employment opportunities, unstable incomes, reduced subsidies, lack of alternative cropping solutions and rather slow development.

Currently, no specific state policy for the energy exploitation of biomass has been introduced in Greece. The instruments and measures utilized to support energy production from biomass are those employed in the broader national policy for the increased penetration of RES in Greece.

At the moment, current bioenergy applications in Greece include:

- Several cotton ginning factories use their residues to produce the heat required for cotton drying and space heating of their facilities. The total heat energy produced has been estimated to 0.4 PJ/year (CRES, 2002).
- The olive kernel wood produced in the olive kernel factories is being used for greenhouse heating, space heating, etc. The total heat energy produced has been estimated to 8.3 PJ/year (CRES, 2002).
- Fruit kernels produced by fruit canneries and shells from almond, walnut and hazelnut peeling plants are being used for greenhouse and residential heating. The annual energy production from these types of residues has been estimated to 0.01 PJ/year (CRES, 2002).
- Rice husk produced is used to produce the heat needed by the rice processing factories and the thermal energy produced has been estimated to 0.09 PJ/year (CRES, 2002). There is also a factory using rice husk for power production with an installed capacity 0.44 MWe.

Taking into account the above mentioned factors and constraints for the agricultural biomass in Greece, the following potential bioenergy applications can be identified (Mardikis et al., 2003):

- Small to medium scale heat generation or cogeneration in the agro-industrial mills
- District heating applications in central-northern high elevation villages
- Co-firing with lignite in the existing power stations
- Hybrid solar & biomass, in the tourist sector (hotels, apartments, etc.)
- Heat generation for individual buildings, e.g. schools, hospitals, public buildings, etc.
- Improved stoves for households based on the different fuel types available in Greece (eg. olive kernels, fruit kernels, etc.)

Agriculture is an important sector of economic activity in Greece, which can be a source of considerable biomass quantities for regional bioenergy schemes. It was estimated that approximately 3.8 million dry tonnes of field crop and arboricultural residues are technically available for energy production as well as 600 000 dry tons of agro-industrial residues, with a respective total energy potential of 69 PJ/year and 10 PJ/year. So far, cultivation of energy crops has not been established for commercial purposes. However, some very promising energy crops have been investigated in several research and development (R&D) programmes. It is expected that biomass use for energy purposes and especially the integration of energy dedicated crops into the local agricultural systems could result to significant social and economic (providing additional income to the farmers or maintaining the present one, maintaining jobs in rural areas, etc.), restructuring of the agricultural sector at both national and regional level.

6.2. Pellets production

There is no current pellet production or use in Greece and therefore the market is still overall undeveloped. Several constrains are existent and all these need to be further identified and documented with the major market actors mostly through personal communication in order to get as mush feedback as possible

6.3. Prices

The current prices of agricultural crop residues in farms are detailed below:

Description	Type of residue	Farm Price Euro/tonne [1]
WHEAT, BARLEY, OAT	STRAW	0.44
CORN	COBS + STALKS	0.75
RICE	STRAW	0.48
LEMON. ORANGE, PEAR, APPLE, PEACH & other TREES	PRUNINGS	30
VINEYARDS	PRUNINGS	30

Industries	Type of residue	Price (Euro / wet tonne) [1]
RICE MILLS	BARK	0,29
PEACH CANNERIES	KERNEL	29
OLIVE KERNEL FACTORIES	OLIVE KERNELS	32,5
PEELING PLANT	WALNUT SHELLS	23,5
PEELING PLANT	ALMOND SHELLS	25
PEELING PLANT	HAZELNUT SHELLS	23,5
WINE FACTORIES	BUNCH	9
WOOD INDUSTRIES	SAWDUST	14,7
FIREWOOD FACTORIES	FIREWOOD	130

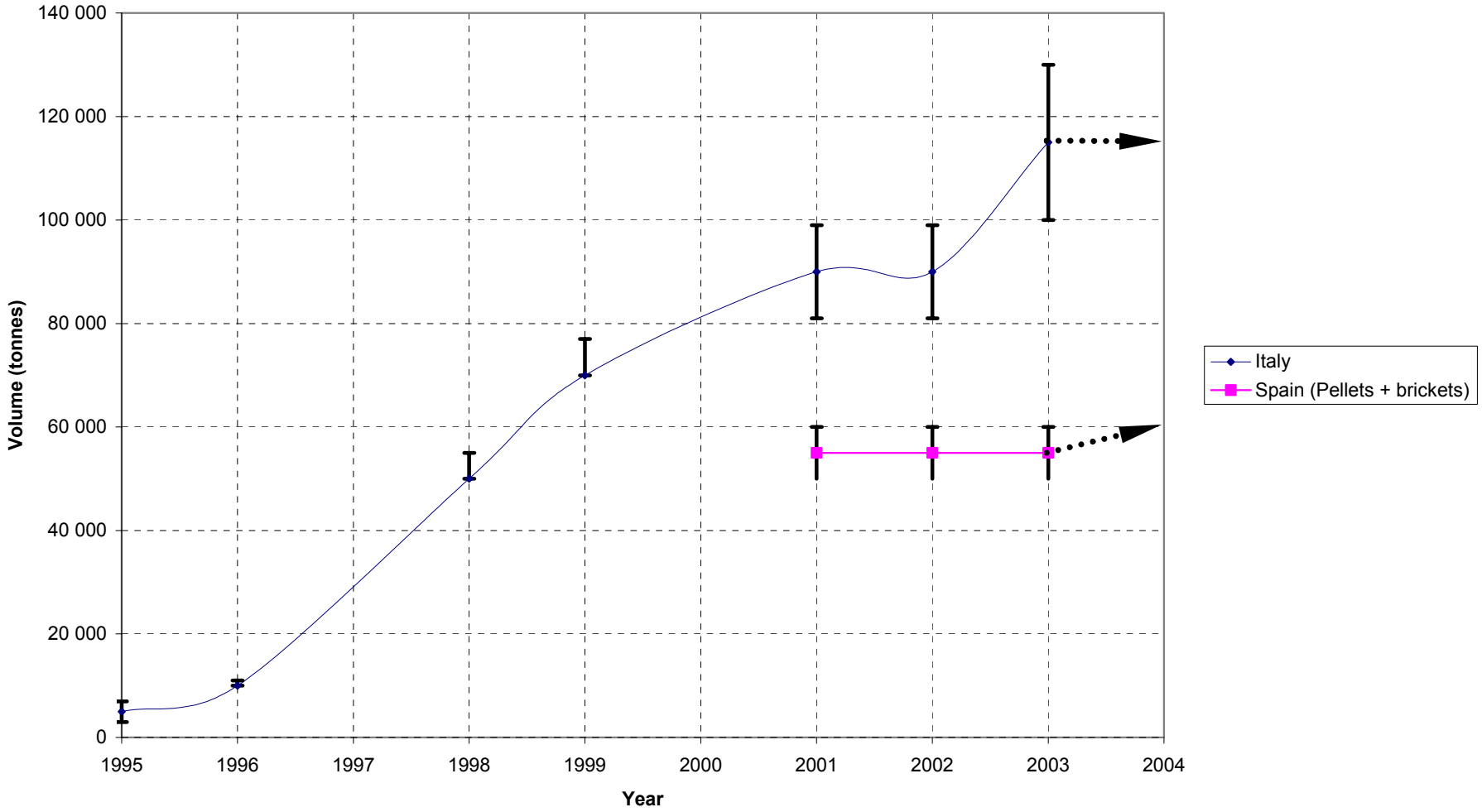
Figure 26, Figure 27 : Prices of agro-industry biomass residues in Greece

[1] Personal communications of CRES – 2003

7. Conclusions and synthesis

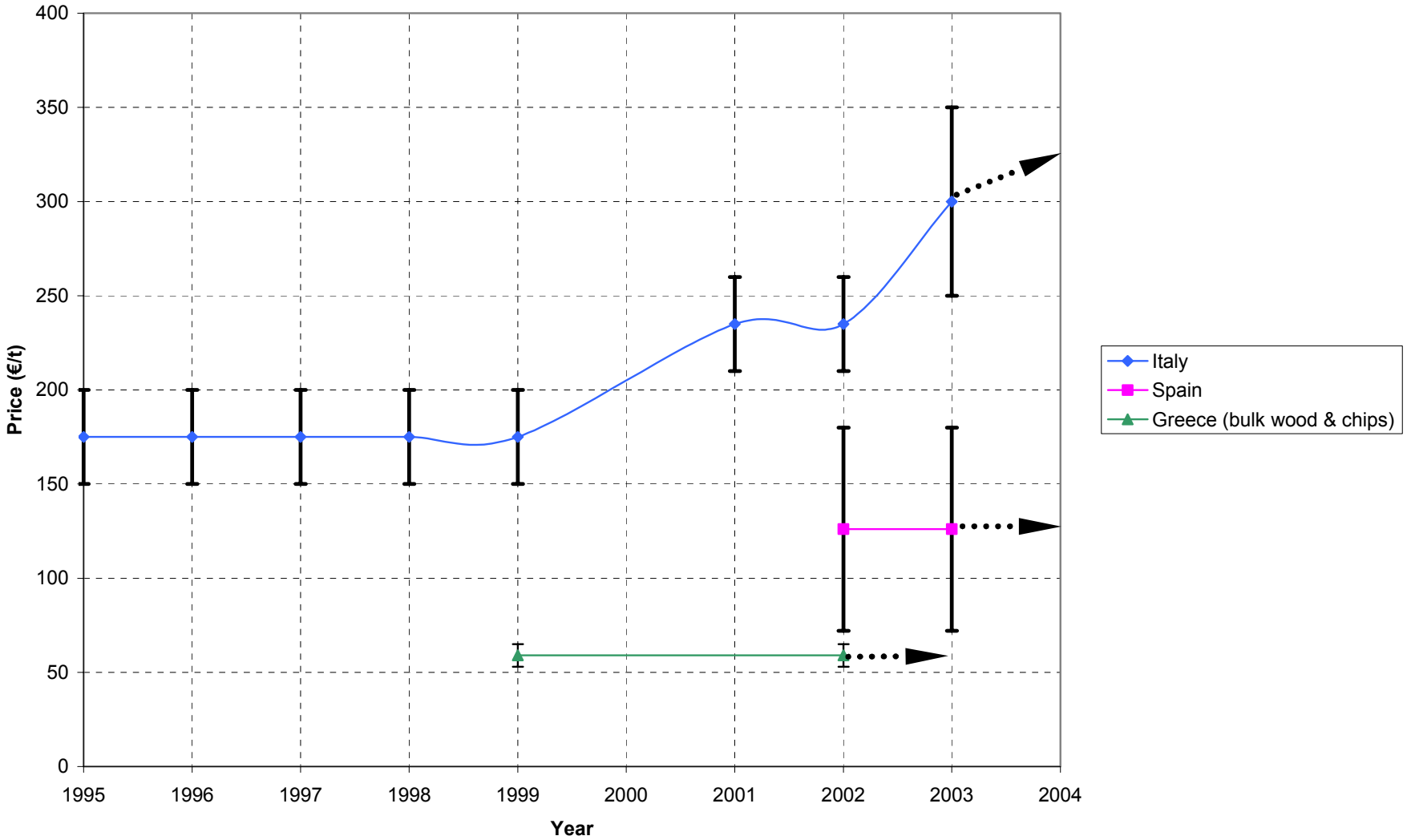
The two figures on the following pages (Figure 28 and Figure 29) highlight the key results from the extensive market analyses in Italy, Spain and Greece. The most notable characteristic that these graphs show is the relative levels of maturity of the three markets. This is discussed below.

Figure 28 : Past, present and future trends in pellet production (and consumption) in Italy and Spain[6].



[6] Figures for Greece are close to zero, although fuel wood consumption is relatively stable at 600-800 thousand tonnes.

Figure 29 : Past, present and future trends in pellets prices in Italy and Spain, and wood prices in Greece.



Italy has by far the most developed pellet market, and one where the supply, demand and price behaviour is dominated by a shortage of wood residues. As a result the supply of wood pellets has reached a plateau, whilst demand is still strong. The result is an unusually strong upward pressure on the pellet price (which is already high by European standards). Pellet supply cannot follow, due to competing demand for raw wood residues. The obvious solutions to this formidable barrier are:

1. To encourage pellets trade with countries with abundant biomass residues and weak demand. Examples of such markets can be found in abundance in Eastern Europe or (in this case) in Spain.

2. To find other raw materials. In particular the potential offered by the exploitation of straw and other agricultural residues must be tapped into.

Both of these measures can and should be implemented in the short- to medium-term, in order to preserve the momentum of the Italian pellet market. This is a momentum which stems largely from the positive image that pellets enjoy amongst entrepreneurs and investors.

Spain suffers mainly from a lack in demand for pellets, due principally to competition from cheaper fuels. Although there is some potential for growth in supply, and the price of pellets is extraordinarily low by European standards, demand is weak. There also appears little prospect for a rapid expansion of demand in the short term, due to an absence of awareness amongst the general population and a lack of political momentum. This offers two solutions:

1. The export of Spanish pellets to nearby countries over land (mainly Italy), or by sea to Northern European countries. This would be a viable measure for the short- and medium-term.

2. The introduction of regional or national financial incentives and levies to increase the competitiveness of pellets as a fuel. This appears unlikely in the current political climate however, and would in any case only be effective in the medium- and long-term-

Greece has a chronically under-developed wood pellet market. The most viable route to a pellet market for Greece appears to be through the adoption of agri-pellets. This however would require political backing and technological innovation in order to lower the price of agri-pellets combustion equipment. On the other hand, the high exploitation of traditional biomass fuels (such as fuel wood) shows the significant opportunity in the Greek market, and a potential widespread acceptance of a solid biomass fuel for domestic and municipal heating.

8. Main references

(In addition to references of Deliverable 16)

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