Report on the availability of Biomass Sources in Spain: vineyards and olive groves

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This report has been made for the EU Project ERANETMED2-72-246: "Direct conversion of Biomass to Electricity in MED area via internal catalytic gasification solid oxide fuel cell" DB-SOFC. This project intends to use residual biomass from vineyards and olive groves in a SOFC for direct production of electricity. DOI10.13140/RG.2.2.32722.66242

1. Biomass in Spain

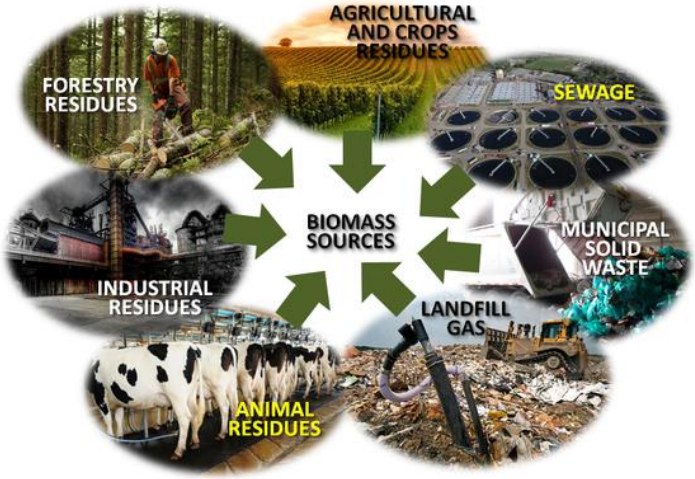

Figure 1.1. Residual biomass sources

Biomass as an energy resource is classified into natural biomass, residual biomass and energy crops. *Natural biomass* is defined as that occurring in nature without human intervention. For example, the natural fall of branches of trees (natural pruning) in forests. *Residual biomass* derives either as by-product or waste from a wide spectrum of human activities. Thus, residues from farming and forestry activities (pruning, stubble, etc.), from agricultural industries (olive kernel, olive pomace, husks, etc.), from wood processing facilities (sawmills, paper mills, furniture, etc.) and (mainly intensive) livestock activities are all residual biomass. Also industrial sectors such as wastewater treatment or municipal solid waste processing generate significant quantities of residual biomass (Figure 1.1). Finally, *energy crops* are a special farming activity specifically devoted to the production of biofuels from different crops, including cereals and beet for production of bioethanol, and oilseeds for biodiesel production. Some woody and herbaceous species are also farmed as energy crops.

In Spain, the potential residual biomass resources from forestry/farming activities and agricultural industries are summarized in Table 1.1. Also in Table 1.1 is depicted the residual biomass exploitation targeted for 2020. It is clear that the residual biomass existing in Spain presents a great potential that is not yet exploited with the maximum efficiency.

Table 1.1. Potential residual biomass in Spain and target values of biomass usage in 2020 [1].

Source		Potential biomass (t/year)	Target for 2020 (t/year)
Existing forest masses	Remains of felling	2984243	9639176
	Full tree use	15731116	
Agricultural remains	Herbaceous	14434566	5908116
	Woody	16118220	
Total		49268145	15547292

The production of residual biomass from wood processing and agricultural industries is depicted in Figure 1.2. Olive oil and wine industries are, respectively, the second and third largest producers of this type of residual biomass in Spain, although both only account for approximately half of the biomass produced from wood processing industries.

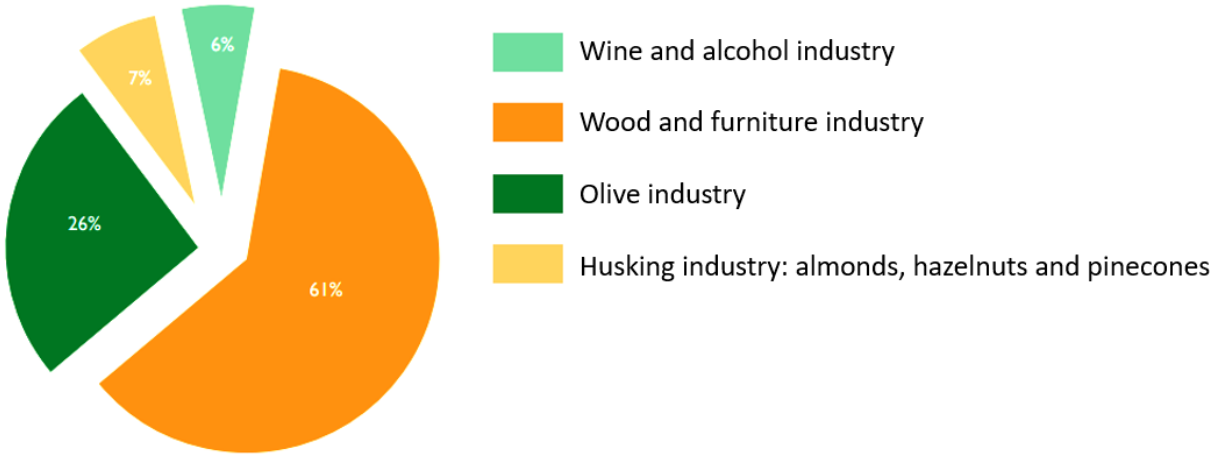

Figure 1.2. Percentage of biomass derived from different industries [1].

The distribution of the residual biomass and energy crops in Spain by type of biomass and region according to the renewable energy action plan for the years 2005-2010 is shown in Figure 1.3.

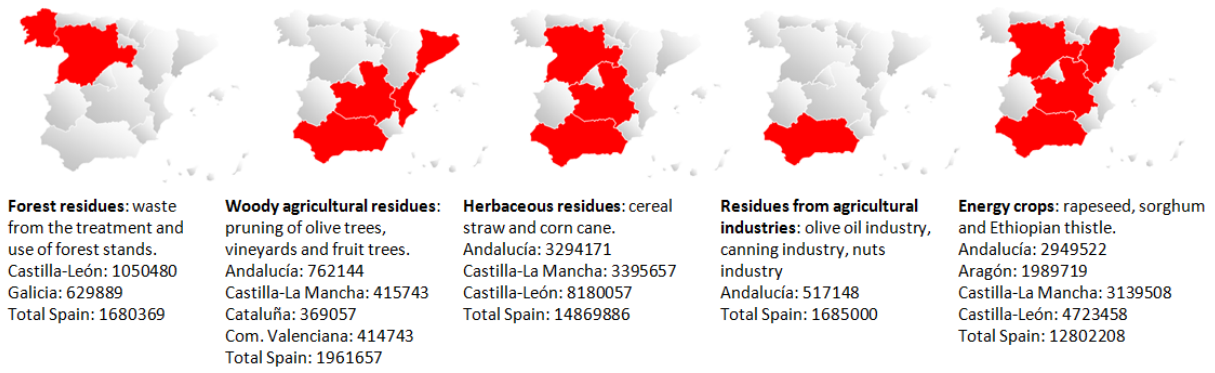

Figure 1.3. Distribution, by type and region, of the residual biomass and energy crops in Spain (in t/y). The areas marked in red correspond to the areas of action of the renewable energy action plan for the years 2005-2010 [2].

According to this the Mediterranean area concentrates the largest production of residual biomass from vineyards and olive groves as well as that derived from the olive oil industry.

The biomass derived from these two crops is depicted in Figures 1.4 and 1.5. It is noteworthy that the production of biomass from olive cultivation is three times more than that produced in the vineyard (in Andalucía), which along with the fact that the olive cultivated hectares in Spain are approximately three times those of vineyards (see 3), makes the production of biomass from olive cultivation significantly higher that of the biomass from the vine crop, which in turn would explains why the degree of industrial use of the biomass from the olive grove is much higher than that from the vineyard, although this has also great potential.

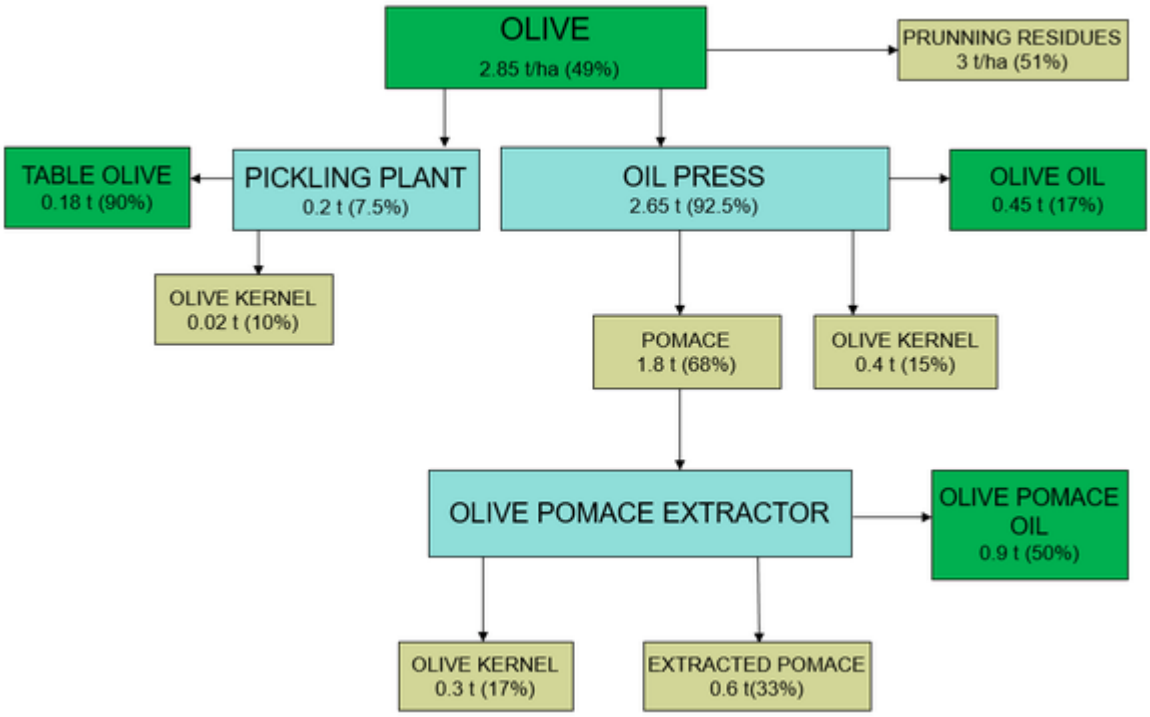

Figure 1.4. Biomass produced from the olive/oil industry. Data are referred to exploitation of the olive grove in Andalucía [3].

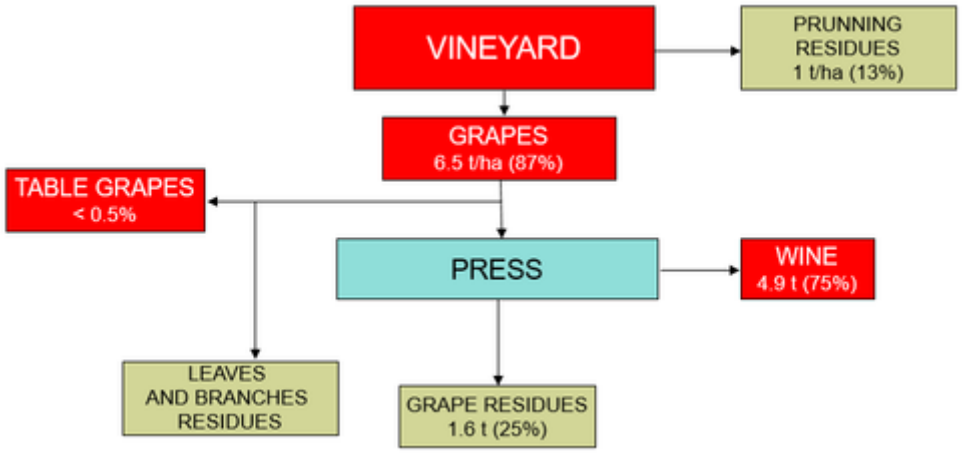

Figure 1.5. Biomass produced in the vineyard and wine industry. Data calculated from [4]

2. Vineyards and olive groves in Spain compared to the European Union

As illustrated in Figure 2.1, Spain is the main producer of olives for olive oil and has the largest cultivated area of vineyards in the European Union, within a total EU production of 10.4 Mt and a total area under vines of 3.19 Mha, respectively. Furthermore, the combination of the different EU countries involved in this current project (i.e. Spain, Greece and Italy) constitute near 90% of the production of olives, and 55% of the vineyards in the European Union. Therefore, it is clear that these two residual biomass have a great potential within the EU energy resources, and consequently it is mandatory the development of efficient technologies for their exploitation.

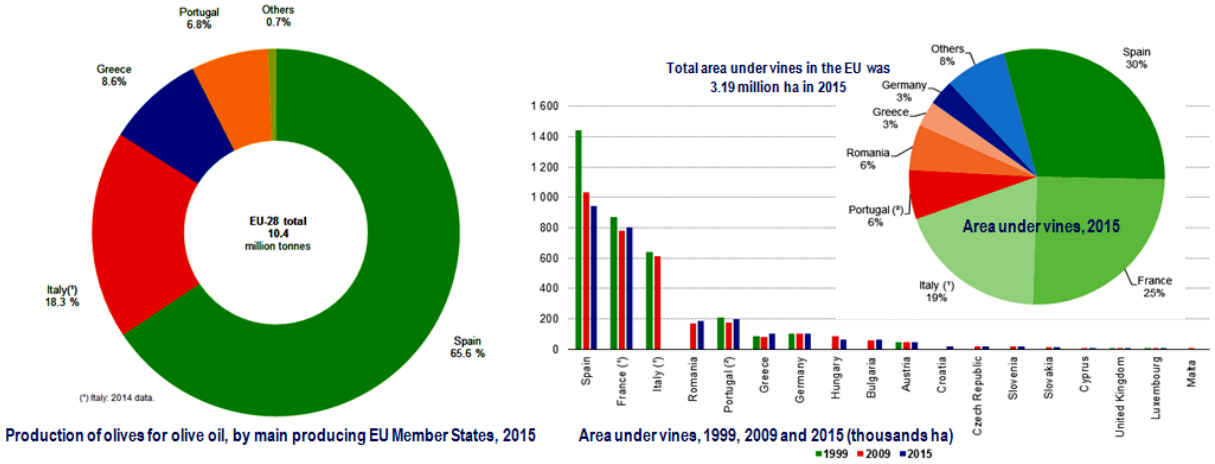

Figure 2.1. Production of olives and area under vines in the main producer countries of EU. Extracted from [5,6].

3. Cultivated areas of vineyards and olive groves in Spain

The surface devoted to vineyards and olive groves in Spain has remained fairly constant during the last seven years, being the number of hectares of olive groves of approximately 2.5 Mha, and that of vineyards of approximately 1 Mha (See Figure 3.1). Therefore, the residual biomass produced by these two crops is a well stabilized and reliable biomass resource.

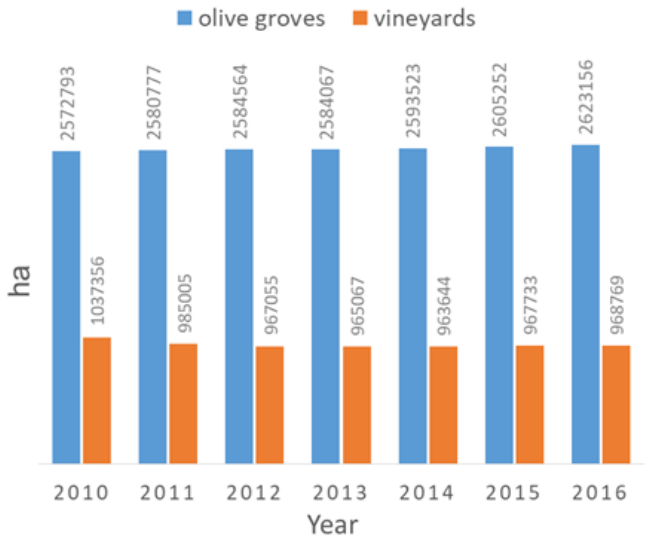

Figure 3.1. Evolution of olive and vine crops in Spain in the last 7 years. Data from [7]:

Within Spanish territory, it is interesting to note that olive crops predominate in Andalucía, Extremadura, Madrid and the Mediterranean area, whilst the surface devoted to vineyards is larger than that dedicated to olives in the center and north regions of Spain, with the exception of Cataluña and Madrid (see Figure 3.2). It has also to be taken into account that the total area used in the production of both crops is considerably larger in the south and Mediterranean regions than in the north (Atlantic regions) of Spain.

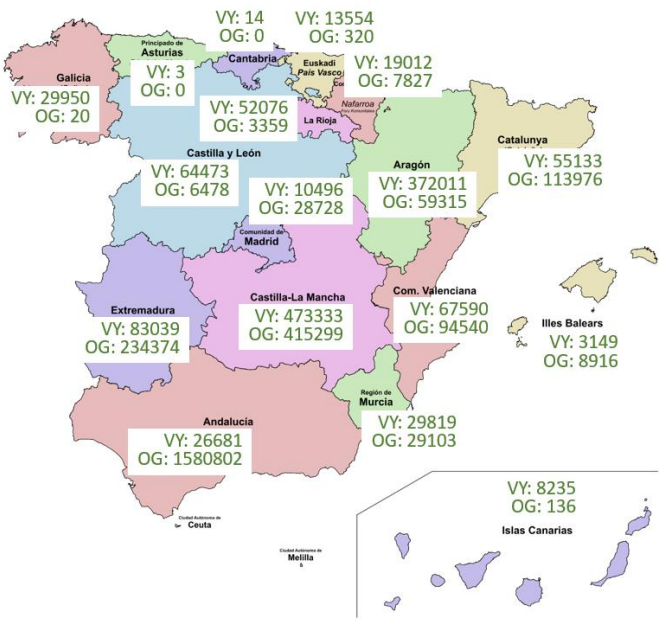

Figure 3.2. Distribution by regions of the hectares cultivated in 2016 of: vineyards (VY) and olive groves (OG). Data from [7].

4. Biomass production in Spain from vineyards and olive groves

It is clear that olives (especially for olive oil production) and wine production are two relevant agricultural activities in Spain and other Mediterranean countries. But how much residual biomass is produced from these activities? Most of the forestry/farming biomass commercialized in Spain (as well as in the UE) is used to produce energy in stoves or boilers. The primary production of energy from biomass and renewable wastes may be used as an estimation of the residual biomass being valorized. As shown in Figure 4.1, Spain occupies the eighth position among the EU countries with approximately 7 Mt of oil equivalent (TOE).

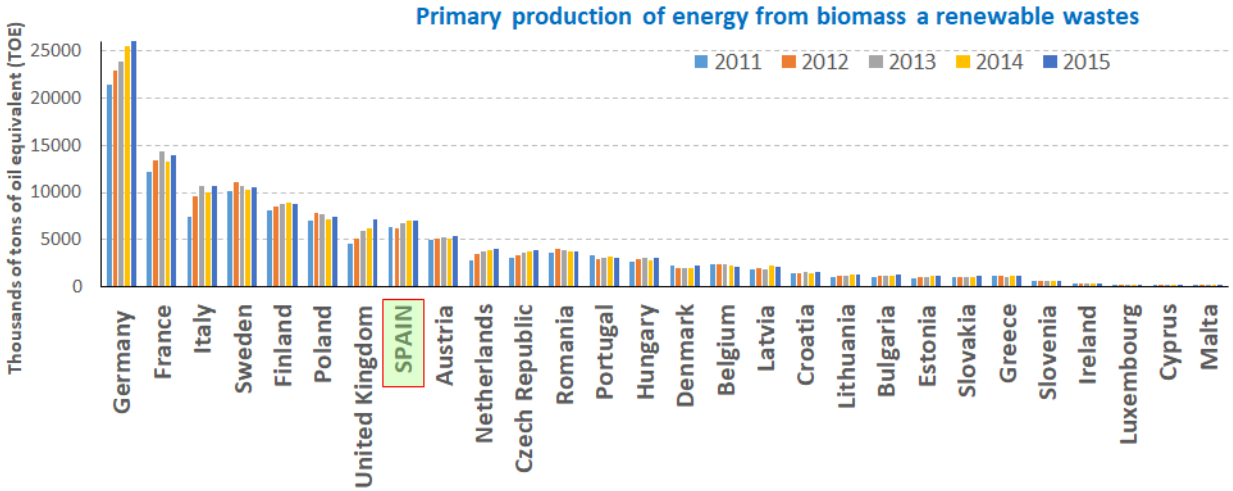

Figure 4.1. Evolution from 2011 to 2015 of the primary production of energy from biomass and renewable wastes in EU countries [8].

Since most of the biomass production for the pellets industry, hence for energy production, is derived from forestry, specific information about the current biomass production derived from the residual biomass of interest in this project (i.e., vineyard and olive groves) is scattered and difficult to find. The

use of olive and, especially, vineyard residues renders, in principle, lower efficiencies of energy recovery when compared to forestry biomass, due to their moisture content and their low heating values (Table 4.1).

Table 4.1. Low heating values of different biomass residues from olive and vineyard crops. Two different moisture contents are considered for each residue [8].

	Moisture (wt%)	LHV (kcal/kg)	Moisture (wt%)	LHV (kcal/kg)
Vineyard pruning	25	2950	50	1770
Vineyard pomace	25	3240	50	1960
Olive pomace	15	3860	35	2810
Olive kernel	15	3780	35	2760

Low heating values of these residues at different moisture contents can be estimated using the following correction factor [9]: ***f = -0.012(wt% moisture) + 1.***

Nonetheless, some estimation based in the average residual biomass yielded by these plantations can be made by using the data collected in Table 4.2. Production is thus estimated from the biomass yield per hectare resulting from the pruning activities. Olive kernel production per hectare is also known (Table 4.2). The estimation is then straightforwardly calculated from the cultivated hectares data shown in Figure 3.2. It should be clear that such estimation gives an idea of the *potential* resources of biomass that could be recovered from vineyards and olive groves. According with such estimation more than 4.5 Mt from each of these agricultural industrial by-products would have been available in 2016.

Table 4.2. An estimation of the production of biomass residues from vineyard and olive groves in Spain (2016). Calculated from data obtained from [3,4,7,10,11]

CROP	Yield (t/ha)	Production (t)
Olive kernel	0.25	655789
Olive pruning	1.5[(1)]	3934734
Vineyard pruning	1.0 (4.7[(1)])	1163000 (4553214[1)])

[(1)] These yields are reported in [10]. A similar yield in residual biomass form olive pruning of 1.45 t/ha is also reported in [12]. However, reference [3] gives a yield of 3 t/ha (in the Andalucía region), while reference [13] reports a yield of 0.9 t/ha of residual biomass for olive pruning and only a yield of 0.3 t/ha for vineyard pruning. These discrepancies come from the different types of crops in the different regions and the different degree of industrialization. In the case of vineyards there is lower industrialization/commercialization of the residual biomass and probably a greater lack of knowledge regarding its potential.

5. Biomass commercialization in Spain

Biomass is a growing market driven by the interest in the use of renewable resources. Figure 5.1 shows the geographic distribution of the biomass pellets plants in Spain. The link leads to an interactive map where the data of each industry can be seen. There is nearly a homogeneous distribution of plants across the country. Practically all pellets plants use natural or residual forestry, mainly from pine wood. However, there are a few companies in Andalucía that already use residues from olive groves and olive oil industry for pellet production for the energy sector. Regarding the industrial exploitation of vineyard pruning, it is practically nonexistent with only a couple of companies that are just starting to use these residues for pellet production (Castilla-La Mancha, La Rioja). Most of these residues from vine pruning are burned nearby where they are produced.

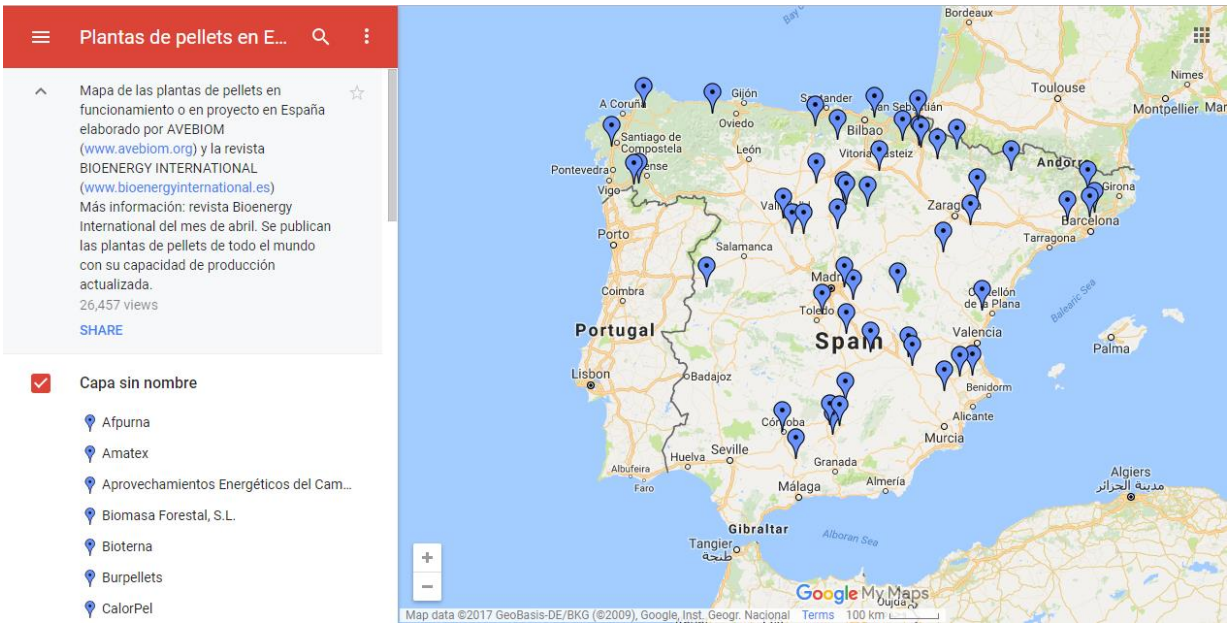

Figure 5.1. Location of the biomass pellet plants in Spain [14]. Click on the image for access to the interactive map online.

One of the greatest difficulties for the industrial exploitation of the biomass of the pruning of the grapevine is the inexistence of appropriate machinery. The EuroPruning project tries to give a solution to this limitation developing new improved logistics for pruning agricultural residues [15]. This type of machinery has been more developed and is more commonly used in the case of intensive olive groves, which contributes to a greater use of this type of biomass [16]. A video displaying different machinery used in the pruning, harvesting and crushing of pruning remains in olive groves and vineyards is shown below.

https://youtu.be/TUlxCIwPR9c

The prices for different biomasses in Spain and its evolution during the last two years are depicted in Figure 5.2. It ranges from 30 to 200 €/t depending on the type and quality of the biomass.

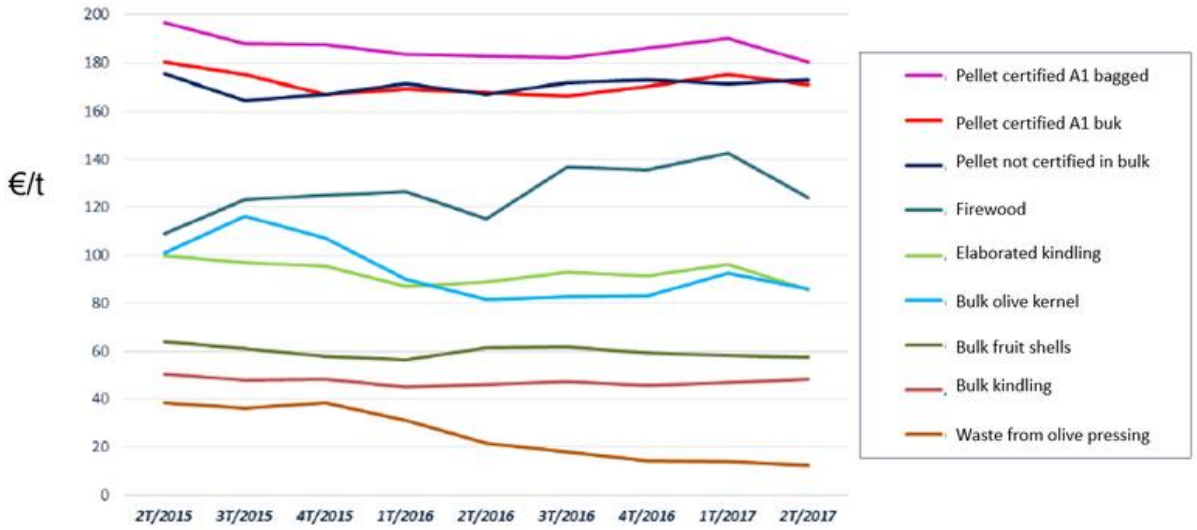

Figure 5.2. Evolution (quarterly) of the average prices of biomass for thermal uses in Spain [17].

6. Conclusions

Spain has an important potential in terms of the use of residual biomass derived from agricultural crops. Specifically, Spain has the largest cultivated area of both vineyards and olive groves in Europe, with a production of biomass from the olive groves that is about 4 times larger than that of vineyards. Thus, the use of biomass derived from olives represents, especially in Andalucía, a significant percentage of the residual biomass pool, although numbers are still far from the total potential of this particular residual biomass. On the other hand, despite the fact that pruning waste from the vineyards is commonly used as a domestic fuel in the vineyard environment, the commercialization or industrial use of residual biomass from the vineyards is practically non-existent, with only a couple of companies that are starting to produce pellets derived from this type of biomass. Finally, almost all of the biomass that is valued and marketed in Spain is made for energy purposes, while other options, such as the production of activated carbon for the elimination of pollutants, have not managed to go beyond the project phase.

7. Acknowledgment

The research leading to this report has received funding from the European Union, Project ERANETMED2-72-246 DB-SOFC.

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