

# Wood Pellets as a Sustainable Energy Alternative in Portugal

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## Abstract

The pellet market in Portugal is a developing market where the main producers of wood pellets try to convince the small-scale buyer that wood pellets are a good alternative as a fuel because energy from them is cost-effective in long-term use. For this work, data about production, production capacity and consumption in Portugal were collected. Consumption levels are low since the majority of sales are exports. The different points of pellet production in Portugal have been located, and a price analysis has been made. To obtain data on the production capacity of the plants and get referrals from the market, the database Bioraise has been used in order to complement the information raised through prospecting and inquiries. Although it is noted that the pellet industry in Portugal is a sector in the initial stage of its development, the potential for growth is high, since internal consumption is low compared to the level of exports to other countries in which the pellet industry is booming. We conclude that the pellet industry is an important alternative in the Portuguese energy market due to the competitive price of this fuel compared to traditional fuels.

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*Keywords:* Wood pellets; wood pellets market; alternative energy; energy costs.

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## 1. Introduction

Actual society development, providing increasing levels of comfort to the people, inevitably leads to an increase in energy consumption in all its forms, requiring a constant and permanent supply. This demand mainly for fossil fuels, traditionally more available and also cheaper, caused a gradual but effective increase in market prices, making it a key factor for competitiveness between countries, since companies competitiveness depends on the energy cost [1-2].

This factor directly interferes with the balance of external transactions, giving advantages to countries or industry sectors that were able to bridge the differential production cost with sustainability measures, using alternative energy sources, improvements and modernization in production processes and measures of energy efficiency control [3-4].

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44 In addition to the direct energy consumption costs, the costs associated with environmental damage  
45 related to fossil fuels consumption are also under the spotlight, mainly those related to greenhouse gases  
46 emissions released into the atmosphere through the combustion of these fuels, especially CO<sub>2</sub>, as the most  
47 recognized by the public, but the list extends to other, equally or more harmful to the environment and the  
48 health of populations than the aforementioned [5].

49 Use of wood pellets as a sustainable energy alternative is an effective instrument in the fight against  
50 climate change [6-7]. It represents a positive globalization of wealth and local employment creation. Wood  
51 as a primary energy source responds to available evidence and to a need for energy, especially relevant at  
52 a time of deep economic crisis, which has forced many to rethink future strategies [8].

53 The most important obstacle in the use of such resources is the high cost of production, supply and  
54 homogenization of use if problems in the various energy conversion technologies are not to be caused [9].

55 Pelletizing is presented as a key factor for the purpose of overcoming this obstacle, and that is why the  
56 wood pellet production industry has experienced considerable economic growth worldwide. Portugal  
57 experienced this development in wood pellet industry with a substantial growth since 2006, when the first  
58 large wood pellets plant (with more than 100.000 t/y capacity) started operation.

59 In the case of Portugal, although there are plants throughout the country, most of them are concentrated  
60 north of Lisbon. The majority of the 38% of the Portuguese territory that consists of forestland is located  
61 there. This forestland is divided mainly into 600,000 hectares of Atlantic pine (*Pinus pinaster*) and 380,000  
62 hectares of eucalyptus (*Eucalyptus globulus*) [28].

63 The most widely used raw material is maritime pine (*Pinus pinaster*), but quantities of eucalyptus  
64 (*Eucalyptus globulus*) are also processed. In the south of Portugal, another type of pine (*Pinus pinea*) is  
65 used because it is more abundant in the region. The critical distance beyond which no one wants to obtain  
66 raw material is in the range of 50 to 70 km. Longer distances cause high transportation costs as materials  
67 are always carried by truck, disabling the interest in the process.

68 Furthermore, the technological development of pellet combustion equipment is growing and becoming  
69 fully automated. Such equipment requires little and or easy maintenance, which makes it very attractive to  
70 the end user, being this one the domestic stove owner or the large industrial steam boiler. In both cases,  
71 many developments were achieved.

72 Undoubtedly, this is a great opportunity that countries in southern Europe, like Portugal, should seize,  
73 mainly due to the fact that forest resources are still abundant and if correctly explored can be really  
74 renewable and sustainable, providing a source of energy that will contribute to the development of rural  
75 areas and jobs creation. Table 1 presents the international context of wood pellet production in 2010 with  
76 forecasts for 2015 and 2020 [10].

77 'See Table 1 at the end of the manuscript'.

78 According to this information, Europe is placed first worldwide in terms of wood pellet production and  
79 is even expected to further increase this advantage [11]. As referred wood pellet market has experienced  
80 tremendous growth in recent years. In 2010, the total world production of wood pellets was 14.3 million  
81 tonnes with a consumption 13.5 million tonnes. This represents an increase of more than 110% compared  
82 to 2006 [12].

83 In 2009, about 670 wood pellet plants were active in Europe, 30% of them with a production smaller  
84 than 10,000 tonnes/year. However, since 2008, the rapid growth in demand has encouraged increases in the  
85 range of several hundred thousand tonnes [13]. Globally, the production capacity of wood pellet plants has  
86 increased: between 2009 and 2011, the global production capacity of the wood pellet industry increased by  
87 22% to 28 million tonnes [14].

88 The European Union is still the main market for wood pellets and will remain so for several years.  
89 Between 2008 and 2010, the production of wood pellets in Europe increased by 20.5% to 9.2 million tonnes  
90 in 2010, with 61% of the world production. In the same period, consumption of wood pellets in Europe  
91 increased by 43.5%, reaching 11.4 million tonnes in 2010 with 85% of global demand [15]. Table 2 presents  
92 the scenario of wood pellet consumption in 2010 with forecasts for 2015 and 2020.

93 'See Table 2 at the end of the manuscript'.

94 While in Europe the sector is making strides, biomass and biomass for thermal applications [16] is key  
95 in countries like Italy, Germany and Austria. Portugal's thermal energy use is comparable to the situation  
96 in other Mediterranean countries like Italy, where the pellet market is purely domestic, with over 1.1 million  
97 pellet stoves installed.

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100 Large plants produce an industrial wood pellet type according to the technical specifications in the  
101 European standard EN 14961 and its updates [17]. Usually, power plants requires an wood pellet of 4–10  
102 mm in diameter with a minimum calorific value of 17 GJ/t, a maximum ash content between 1 and 3%, a  
103 low bulk density of 500 to 600 kg/m<sup>3</sup> and less than 10% moisture, among other specifications [18].

104

## 105 **2. Portuguese wood pellets market**

106 The wood pellet market in Portugal is at an early stage of development as it is not well structured, lacks  
107 domestic consumption and most of the production is exported abroad to northern European countries like  
108 England, Denmark, Belgium or Sweden [10].

109 The Portuguese pellet market consists of small direct consumers with small and medium peaks in the  
110 winter period from October to April [19]. The main consuming sectors for pellets in Portugal are the  
111 domestic sector and public services and industries with thermal energy needs. This includes large building  
112 heating systems, i.e. bakeries and other similar facilities. In this sector, the largest consumers are mainly  
113 elderly care centres, schools and sports facilities.

114 Fig. 1 presents an example of a 300 kW<sub>th</sub> set of boilers used for heating in an elderly care centre located  
115 in the north Portugal. This particular case can be used as an example since this situation may contribute to  
116 cost reduction in other similar cases, and at the same time can be extrapolated to schools, hospitals, or any  
117 other type of service buildings. Table 3 presents the results obtained in this case study.

118 'See Fig. 1 at the end of the manuscript'.

119 'See Table 3 at the end of the manuscript'.

120 This situation in particular can be presented as a worst case scenario possible to find, mainly due to the  
121 large amount of extra works needed to allow the installation of new boilers and its connection to the already  
122 existing heating system, very old and obsolete. These extra works increase several times the necessary  
123 investment. In other situations analysed, the necessary investment was found to be, in the majority of the  
124 cases, less than half of the presented here. In this particular case it was not possible to adapt the already  
125 existing equipment due to technical incapacity of those, being replaced for brand new boilers. But even  
126 with these eventualities the investment pay-back period was 2.5 years and it is considered to be acceptable  
127 for this amount of investment.

128 More recently, a new group of consumers has emerged. Due to their large thermal energy needs, they  
129 are looking for cheaper and more sustainable forms of energy. This group includes textile dyeing plants,  
130 which are very important for the Portuguese economy [20-21]. An example of a biomass system adapted  
131 to an industrial steam boiler located in a textile dyeing company in north Portugal is presented in Fig. 2,  
132 Fig. 3 and Fig. 4.

133 'See Fig. 2 at the end of the manuscript'.

134 'See Fig. 3 at the end of the manuscript'.

135 'See Fig. 4 at the end of the manuscript'.

136 The use of biomass as an energy source, renewable-oriented and of national production, presents also  
137 the possibility of exploitation of an endogenous natural resource, not subject to international price  
138 fluctuations due to constraints in the global markets, since it is not dependent on factors connected to  
139 external geopolitical stability, but rather, and only, subject to the laws of supply and demand of the national  
140 market itself.

141 A recent study [22], conducted in the Portuguese textile dyeing industry, shows that an energy market  
142 designed to provide continuous and permanent thermal energy to the industrial sector in question allows  
143 itself the sustainability of the forestry sector developed for the purpose, since the amounts involved to the  
144 full satisfaction of the needs of a textile dyeing company with a 8 t/h steam boiler are about 5,000 t/y of  
145 wood pellets with a market value of 725,000.00€, as shown in Table 4. The same study concludes that the  
146 replacement of traditional fossil fuels by biomass produces practical effect on direct savings estimated on  
147 18% in the energy costs for textile dyeing companies. The replacement of traditional fossil fuels by biomass  
148 requires that companies undertake changes, or even full replacement of equipment, leading to investment.  
149 Table 5 shows an estimation of the required investment to replace existing steam boilers for a new biomass  
150 equipment, including all peripherals such as solid particles removal cyclones, economizers, fuel silos and  
151 loading system, as well as an estimation of the payback period [22].

152 'See Table 4 at the end of the manuscript'.

153 'See Table 5 at the end of the manuscript'.

154 The international economic crisis and the difficulty that companies resort to sources of credit and  
155 financing makes this to be a difficult issue to overcome for many companies and could preclude the  
156 adoption of biomass as an energy source, if there is no support for the energy conversion.

157 In Portugal, there are no thermal power plants using wood pellets as fuel and the term '*district heating*'  
158 is not implemented due mainly to the temperate climate that characterizes the country but also because  
159 legislation forcing the repartition of resources in new residential areas has not been implemented. Such  
160 legislation would be beneficial. For example, when a project for a new residential neighbourhood is  
161 presented for approval, it could be mandatory to include a mutual heating system for all the new houses.  
162 This situation should be applied to all new blocks of apartments. With measures like these, the consumption  
163 of pellets would increase rapidly.

164 Pellet production in Portugal has increased from 2005 to the present, from just a few very small plants  
165 to several large ones in just a few years [23].

166 The growth in the production rate has seen an exponential increase, especially when considering  
167 production capacity. However, this has not been associated with increased domestic consumption. In fact,  
168 domestic consumption is negligible, although sales of stoves and boilers are increasing.

169 In the last four years, Portugal reached an installed capacity of more than one million tonnes per year.  
170 There are two different factors in the wood pellet industry in Portugal. First, large factories of over 100,000  
171 tonnes annual capacity are export-oriented and export industrial pellets to large European consumers. These  
172 factories are mainly owned by large energy investors with little or no previous connection to forestry or the  
173 wood industry [24].

174 Second, medium and small sized wood pellet plants of 4,000 to 50,000 tonnes/year produce wood pellets  
175 as a part of or as a 'logical' extension of their production processes because they have direct access to  
176 biomass waste. For example, pallet production plants, sawmills, the furniture industry or the cork industry,  
177 supply their pellet production to the local residential and small industries market [25].

178 The majority of the production plants, large and small, now operating in Portugal or in commission,  
179 began their activities in the last four years. Rising oil prices and subvention programs for 'green' energy in  
180 coal power plants in many European countries have raised the expectation of an interesting business in the  
181 supply of this form of biofuel [26].

182

### 183 **3. Materials and methods**

184 To study the current situation of the production of pellets and the market in Portugal, the Bioraise  
185 database has been used [27].

186 The data obtained from the Bioraise database were then confirmed through direct contact with wood  
187 pellet producers and, in the majority of cases, with visits to the facilities. In this study were also included  
188 the wood or biomass pellet plants still under construction.

189 For price information, direct quotations have been obtained from all the producers, and information was  
190 also collected in supermarkets and other retailers.

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#### 193 **4. Results and discussion**

194 The wood pellets industry in Portugal consists of 9 plants of large capacity (> 100,000 t/y) and 18 small  
195 or medium plants (< 40,000 t/y) with a total installed production capacity of 1,200,000 t/y. All the large  
196 plants are based on pulpwood or wood chips as the main raw materials, while the small and medium plants  
197 use mostly dry materials. Domestic pellet type production increased steadily from 120,000 t/y in 2006 and  
198 reached 1,200,000 t/y in 2012 [29]. The consumption of wood pellets has grown at a much slower pace and  
199 is estimated to be 150,000 t/y in 2015.

200 The majority of the wood pellet plants with a production capacity exceeding 100,000 tonnes are located  
201 along a line of 150 km in the districts of Coimbra and Castelo Branco. Table 6 presents the entire list of  
202 active or commissioning wood pellet plants in Portugal.

203 'See Table 6 at the end of the manuscript'.

204 For these figures, wood pellets represent a very small fraction of the energy market in Portugal, yet.  
205 About 10% of the market is for pellet stoves in private households and for industrial boilers, mainly  
206 operating in the textile industry, while 90% is exported in bulk for northern European countries like  
207 Belgium, Sweden or Denmark [30].

208 The large plants almost exclusively produce industrial type pellets, but almost all have plans to expand  
209 their production lines with the installation of residential type pellets with bagging. The aim is to sell bags  
210 of 15 kg in the domestic and European markets. This would involve bagging lines of up to 800 bags per  
211 hour. Small production plants sell part of their production in Portugal for the domestic home market but  
212 also for small industries, such as bakeries, restaurants, hotels, schools, elderly homes and swimming pools.  
213 As the domestic market is very small, the rest of the production is exported to other European countries in  
214 15 kg bags to be sold in large commercial centres.

215 All major national companies focus on exporting pellets because the domestic market cannot absorb the  
216 entire production. The main countries to which Portugal exports its output are the countries of northern  
217 Europe, with main emphasis on England, Denmark and Sweden. The needs of the internal market are  
218 exclusively ensured by domestic production, so that imports are almost non-existent.

219 To counteract this trend, it is necessary to promote wood pellets and heating equipment, so that the  
220 market can develop in a similar way to the Italian model, for example. To achieve this, the example of  
221 public administration can be a major help to change mentalities.

222 Boiler replacement, the adjustment of structures for the use of alternative fuels and negotiating supply  
223 and maintenance contracts with private operators could allow municipalities to have more money for other  
224 purposes such as social support, the creation of new infrastructures or the restoration of others.

225 In Portugal, the selling price of the residential pellet type in supermarkets ranges between 3.5€ to 5€,  
226 including VAT for 15 kg bags. The price of residential pellet types sold in bulk varies between 155€ and  
227 185€, excluding VAT, depending on the type of contract, because may include other services like boiler  
228 maintenance or ashes cleaning, and the quantities supplied. As for industrial pellet types sold in bulk for  
229 export, the price varies between 125€ and 160€, depending on the quantity, quality and calorific value.

230 Table 7 allows comparing the most common fuels used in Portugal for domestic and industrial  
231 applications, mainly for heating purposes, since in Portugal due to low feed-in-tariff for energy production  
232 it is not yet financially attractive, by opposition to what happens for example in England where, due to a  
233 feed-in-tariff of £105/MWh<sub>e</sub> (approximately 148 €/MWh<sub>e</sub>), it is highly compensatory to produce electric  
234 energy from biomass and the conversion of coal-fuelled power plants to solely biomass burning units is  
235 already a reality [31]. In Portugal, for existing biomass plants, the indicative average rate is € 119 per MWh<sub>e</sub>  
236 [32]. With such a feed-in-tariff it is not possible to promote the use of wood pellets to energy production,  
237 comparing to other countries where it is more attractive to export national wood pellets production.

238 'See Table 7 at the end of the manuscript'.

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## 244 **5. Conclusions**

245 Solid biomass, and in particular wood pellets, has become the most competitive fuel for the end user.  
246 According to projections for Portugal and other European countries, wood pellets represent a stable and  
247 cheap energy alternative. This motivates the development of the use of biomass for thermal energy. In  
248 conclusion, it can be stated that the industry of wood pellet production in Portugal is a young industry still  
249 to be explored. Due to the competitive price of wood pellets compared to other traditional fuels, the pellets  
250 are an important alternative in the energy market, especially compared to thermal energy production.  
251 Concerning energy production, it is not yet interesting due to the low feed-in-tariff in practice in Portugal.  
252 The average rate of 119 €/MWh<sub>e</sub> is much lower than the 148 €/MWh<sub>e</sub> in practice in England, for example.  
253 Due to this difference it is still preferable to national wood pellets producers to export to North European  
254 countries.

255

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261

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332 **Figure captions**  
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Fig. 1. Example of a heating system in an elderly care centre in north Portugal, composed of two 150 kW<sub>th</sub> boilers.



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Fig. 2. Biomass system in a textile dyeing plant in north Portugal –wood pellet storage.



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Fig. 3. Biomass system in a textile dyeing plant in north Portugal –wood pellet feeding.



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Fig. 4. Biomass system in a textile dyeing plant in north Portugal – steam boiler.

350 **Tables**

351

352 Table 1.

353 Wood pellets production (x1,000,000 t/y) in 2010 and forecasts for 2015 and 2020 (adapted from [10]).

354

<b>Regions</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>
North America	4.9	8.5	11.0
South America	0.1	3.0	4.4
Western Europe	7.7	10.7	13.0
Eastern Europe	2.2	2.8	3.3
Russia	0.6	1.4	1.6
Japan & Korea	0.1	0.4	1.1
China	0.6	3.0	10.0
Oceania	0.2	0.4	0.8

355

356 Table 2.

357 Wood pellets consumption (x1,000,000 t/y) in 2010 and forecasts for 2015 and 2020 (adapted from [10]).

358

<b>Regions</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>
North America	3.4	4.3	5.6
South America	0.05	0.12	0.20
Western Europe	10.8	16.4	23.8
Eastern Europe	0.4	0.6	0.8
Russia	0.03	0.05	0.05
Japan & Korea	0.2	3.0	5.5
China	0.6	3.0	10.0
Oceania	0.03	0.06	0.13

359

360 Table 3.

361 Investment pay-back.

362

<b>Previous annual propane gas consumption (*)</b>	<b>Investment in biomass boiler (**)</b>	<b>Actual wood pellets consumption (***)</b>	<b>Investment pay-back</b>
45,000 €/y	80,000 €	14,000 €/y	2.5 years

\* The average market price of propane gas used in the study was 1.75 €/kg and a LHV of 12.86 kW/kg.

\*\* This investment corresponds to the full replacement of the equipment.

\*\*\* The average market price of wood pellets used in the study was 0.22 €/kg and a LHV of 5 kW/kg. This price includes transportation and boiler cleaning and maintenance.

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365 Table 4.  
 366 Estimated annual average values of wood pellets consumption (adapted from [22]).  
 367

<b>Wood pellets consumption</b>	<b>Annual average (11 months)</b>	
	<b>Natural gas</b>	<b>Wood pellets</b>
Fuel consumption on steam production (corresponding to 60% of total energy consumption in the industrial unit)	1,925,000 m <sup>3</sup>	5,000,000 kg
Steam production costs	825,000€	725,000€
kWh <sub>th</sub> costs	0.034 €/kWh <sub>th</sub>	0.030 €/kWh <sub>th</sub>

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 370 Table 5.  
 371 Investment needs for the replacement of steam boilers and payback period estimation.  
 372

<b>Steam production boiler capacity</b>	<b>Investment</b>	<b>Payback estimation [22] (y)</b>
5 t/h	350,000€	2.8
10 t/h	700,000€	3.2
15 t/h	1,000,000€	3.6

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374 Table 6.  
 375 List of the active or commissioning wood pellet or biomass pellet plants in Portugal.  
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Wood or biomass pellet plants	Location	Capacity (kg/y)
ADL	Celorico de Basto	20.000
AFS *	Oliveira de Azeméis	100.000
Biobranco II	Vila Velha de Rodão	50.000
Biomad	Guimarães	5.000
Briquetes Raro	Vila Nova de Gaia	10.000
Castro & Filhos	Guimarães	5.000
CMC Biomassa	Alcobaça	10.000
Douropellets	Lamego	10.000
Enermontijo	Pegões	120.000
Enerpellets	Pegrogão Grande	150.000
Fourpellets	Barcelos	5.000
Glowood	Cercal do Alentejo	50.000
JAF/Nova Lenha	Oleiros	80.000
Jungle Power	Lousada	120.000
Melpellets	Melgaço	5.000
Nicepellets	Ilhavo	5.000
Omnipellets	Leiria	40.000
Pellets Power	Mortágua	100.000
Pellets Power 2	Alcácer do Sal	100.000
Pelletsfirst	Alcobaça	120.000
Pinewells	Arganil	120.000
Sol Total	Coimbra	10.000
Stellep	Chaves	40.000
Tecpellets	Póvoa de Varzim	100.000
Thermowall II	Braga	5.000
Vimasol	Celorico de Basto	10.000
XPZ	Esposende	5.000
YGE*	Oliveira de Azeméis	5.000

\* Torrefied biomass pellets

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379 Table 7.  
 380 Comparison between the most common fuels used in Portugal.  
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<b>Fuel</b>	<b>LHV (*) (kWh)</b>	<b>Average price 2015</b>	
		<b>Domestic market</b>	<b>Industrial market</b>
Wood pellets	4.97	0.035 €/kWh	0.030 €/kWh
Natural gas	9.16	0.079 €/kWh	0.034 €/kWh
Heating diesel	7.90	0.141 €/kWh	-
Propane gas	11.20	0.349 €/kWh	0.121 €/kWh
Thin fuel oil	11.39	-	0.067 €/kWh

LHV – Low Heating Value in kWh.

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