

Analysis of the use of biomass as an energy alternative for the Portuguese textile dyeing industry

L.J.R. Nunes ^a, J.C.O. Matias ^a, J.P.S. Catalão ^{a,b,c*}

^a University of Beira Interior, R. Fonte do Lameiro, 6201-001 Covilha, Portugal

^b INESC-ID, R. Alves Redol, 9, 1000-029 Lisbon, Portugal

^c IST, University of Lisbon, Av. Rovisco Pais, 1, 1049-001 Lisbon, Portugal

Abstract

The energy efficiency and the development of environmentally correct policies are current topics, especially when applied to the industrial sector with the objective of increasing the competitiveness of the enterprises. Portuguese textile dyeing sector, being a major consumer sector of primary energy, needs to adopt measures to improve its competitiveness. Biomass appears to be a viable and preferred alternative energy source for the sector, while simultaneously develops an entire forest industry devoted to the supply of forest solid fuels. This work carries out a comprehensive PEST analysis, which analyses Political, Economic, Social and Technological aspects of the replacement of the fossil fuels traditionally used in this sector by biomass, providing a framework of environmental factors that influence the strategic management of the companies. The main advantages are the reduction of external dependence on imported fuel due to the use of an endogenous renewable resource, the creation and preservation of jobs, the increased competitiveness of the sector by reducing energy costs, the use of national technology and the reduction of greenhouse gases emissions.

Keywords: PEST analysis, biomass, textile dyeing industry, energy costs

1. Introduction

The intensity with which modern society develops, providing increasing levels of comfort to the people, inevitably leads to an increase in energy consumption in all its forms and shapes, requiring a constant and permanent supply.

This demand mainly for fossil fuels, traditionally more available and also cheaper, caused a gradual but effective climb in market prices, making it a key factor for competitiveness between countries, since companies competitiveness depends on the energy cost. 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 [1-4].

In addition to the direct energy consumption costs, the costs associated with environmental damage related to fossil fuels consumption are also under the spotlight, mainly those related to greenhouse gases emissions released into the atmosphere through the combustion of these fuels, especially CO₂ and SO₂, as the most recognized by the public, but the list extends to other, equally or more harmful to the environment and the health of populations than the aforementioned [5].

* Corresponding author at: University of Beira Interior, R. Fonte do Lameiro, 6201-001 Covilha, Portugal. Tel.: +351 275 329914; fax: +351 275 329972.
E-mail address: catalao@ubi.pt (J.P.S. Catalão).

The industry is, on a global scale, the main energy-consuming sector in all its forms, especially electricity and thermal energy for the simple operation of production lines, or for direct use in production processes, requiring a careful analysis of consumption and perception production processes, so can be found alternatives that mitigate energy costs [6-7].

The textile industry, one of the most important sectors of the economy worldwide, and for being one of the activities that benefited most from the Industrial Revolution, came over the past two centuries undergoing profound changes, accompanying the rhythm of the technological innovations that have occurred over the years, triggered by the reaction to new situations and adversities [8].

Because it is a complex industry and consists of different technical areas within their different production processes, this work aims to focus exclusively in textile dyeing, which is a major consumer of energy, especially thermal energy, once is directly used in the production process.

The textile industry has, in Portugal, a place of prominence in the economy and businesses, with over 150 years of large-scale productive activity, and in some periods of the country's recent history has been the main employer sector, and also the most important to foreign trade balance [9].

The textile dyeing, being a key part of the finishing sector, is assumed as an area of increasing development, in which the difference by the quality of the final product bring gains from the economic point of view, justifying for its own an individual analysis of the sector [10].

It is possible to find in the literature some recent studies that address issues related to measures for the improvement of production processes in this sector, and also other studies that analyse energy efficiency actions [8], or that characterize the point of view of consumption [11]. However, there were no studies reflecting on the implications of the replacement of traditional forms of energy used in the sector of textile dyeing by new forms, especially by biomass [12].

Thus, the aim of this work is to provide a Political, Economic, Social and Technological (PEST) analysis, making a characterization of the process of replacing fossil fuels by biomass in the Portuguese textile dyeing industry, addressing all aspects of political, economic, social and technological developments that are implicit and associated with this process.

This study, after this introductory note which makes the characterization of the industrial sector and energy consumption of Portuguese textile dyeing industry, as well as an approach to environmental aspects involved, is followed by a PEST analysis, which analyses political, economic, social and technological developments related to the use of biomass as a sustainable energy alternative, and the conclusion, which summarizes the obtained results.

2. Characterization of the Portuguese textile dyeing industry

2.1. The textile industrial sector

The textile industry is a fragmented and heterogeneous sector dominated mainly by small and medium enterprises, divided by the three main uses: clothing, home textiles and industrial use [13].

This sector represents in the European Union [14]:

- 3.4 % of the production of the manufacturing industry;
- 3.8% of economic value added;
- 6.9 % of industrial employment.

The activities of the textile industry are distributed throughout Europe, but are more concentrated in some EU countries. Italy is the main European producer, far ahead of Germany, UK, France and Spain. These five countries account for over 80% of textile companies in the European Union, which in 2000 reached a turnover of €198 billion, employing about 2.2 million people [15]. In Portugal, the location of textile enterprises occurs mainly in the north of the country [16-17].

The textile and clothing chain is composed of a large number of sub-sectors that encompass the entire production cycle, from production of raw materials (synthetic or natural fibres), semi-processed materials (yarn , woven and knitted fabrics) and final consumer products (textiles clothing and industrial use) [18].

2.2. The energetic situation in the sector

In terms of energy, the textile industry in 2009, representing about 6.25 % of the total energy consumed in the manufacturing industries of Portugal, which accounted for 20.4 % of final energy consumption in the country [19]. The textile industry is traditionally an industry with intensive energy expenditures. In general in the textile industry, energy is used especially in the form of [20]:

- Electricity: for machinery, lighting, office equipment and others.
- Liquid or gaseous fuels: Naphtha, propane or natural gas for thermal power equipment.

The textile manufacturing sectors with the highest weight in energy consumption are the finishing and dyeing, when compared with other sectors. The thermal component is much greater than the electrical component in these sectors, and the implementation of thermal energy conservation measures becomes imperative [21]. In fact, Portugal starts to notice a decrease in total energy consumption (coal, oil, electricity, natural gas) since 2000 [22]. Note that this reduction is certainly linked to decrease in production, but also the energy rationalization measures taken by the industry in an attempt to reduce costs and comply with approved plans for energy rationalization [23].

The costs of electricity and especially oil have increased markedly in recent years, so the energy conservation has become a key issue. Before the energy issue has become relevant energy losses by the discharges of hot water, leaks and improper maintenance, lack of insulation on pipes and machinery, non-recovery of gas and hot air and improper settings of high-energy consumption were common occurrences in the textile industry [24-25]. These losses were generally neglected due to the pressures arising from the production and delivery times. Rising energy costs have made these occurrences unsustainable, both in terms of profitability (since the cost of energy plays a crucial role in the overall processing cost, which can go up to 30 %), and in terms of the corresponding environmental concern [26-27].

In 2009, the form of energy used by most Portuguese textile industry was the natural gas needed to fuel the boilers that produce steam for sectors with higher thermal requirements, such as dry cleaning and dyeing and where natural gas replaced almost completely naphtha, minimizing maintenance costs for boilers, besides being a more "cleaner" energy [28].

2.3. The Portuguese textile dyeing industry

The Portuguese textile dyeing industry is a sector of fundamental importance to the national economic outlook, with a number of large companies, mainly concentrated in the municipalities of Guimarães, Vizela, Santo Tirso, Famalicão and Barcelos, in the north of Portugal in the Ave and Cávado valleys. This industrial sector represents 9% of Portuguese exportations, 20% of the employment in manufacturing industries and 8% of the total production in manufacturing industries in Portugal [29].

This sector went through a period of decline, which led to the closure of many industrial units, some large, even within the European panorama, and also the realignment and reconditioning of many other companies, who have been forced to drastically reduce its number of employees in order to maintain their activity during the most intense period of international crisis which still lives [30].

Many of these companies followed, however, the path of modernization with the introduction of effective requalification programs of its production processes and implementing action plans for energy efficiency, which allowed leverage on the quality of products and significantly increased production, contributing at the same time to the reduction of production costs, thus increasing the competitiveness of the companies [31].

This sector currently, and result of the reindustrialization actions carried out in recent years, reached the limit of cost reduction with everything that is related directly to labour costs, since in the case of raw materials these are regulated by open and competitive markets on a global scale, so only left as a last option for improvement of competitiveness, reducing energy costs, directly related to the cost of fuel used [32].

The major source of energy consumption in this industry relates to the production of steam used in the manufacturing process, reaching energy costs for this purpose to about 60% of the total energy consumption of each industrial unit of this kind [33].

The most common steam boilers used for this manufacturing process consume as fuel mainly natural gas, still existing, however, many boilers consuming propane and even naphtha, mainly in companies located far from the natural gas national network and where the supply is not possible [34]. In fact, in recent years with the objective of reducing energy costs of these companies passed by the replacement of propane and mainly naphtha burners to natural gas burners [35]. Figures 1, 2 and 3 show some examples of burners of natural gas, propane and naphtha installed in steam production boilers belonging to textile dyeing companies.

See Fig. 1 at the end of the manuscript.

See Fig. 2 at the end of the manuscript.

See Fig. 3 at the end of the manuscript.

These companies, many of them having already decades of continuous operation, grew to fulfil the needs of the moment, and very rare are the cases which prepared development plans predicting future situations. For example, it is very common to find companies that have multiple boilers, which have to work simultaneously to meet the needs of the production line because the boilers were added as the production increased. At the level of the manufacturing facilities there is an overlap of different spaces, still coexisting original facilities of the company, with newer spaces, built to fill momentary growth needs, where the hits logistics and organization are sometimes difficult to combine.

The management of these companies, often familial in nature, is handed over to a type of businessman who grew up in the middle of the textile industry over generations and completely dominates the production process, and is now assisted by highly qualified technicians from other areas of knowledge that help in decision making at the level of the production (process), financial and commercial areas. Regarding the decision-making related to development of strategic plans there is still a deep lack [36].

It is a sector that is slowly showing signs of improvement and recovery, contributing significantly to the volume of national exports, especially high-quality products classified in the segment of medium and high range, being sought by major international brands for the execution of orders that satisfy the most demanding markets [37].

This sector has long assumed its responsibilities in terms of production in compliance with environmental and labour standards, which is one of the factors most frequently mentioned by entrepreneurs when faced with issues of competition from other countries, where the same rules are not met and that cause competitive disadvantages [38].

3. PEST Analysis to the replacement of traditional fuels by biomass in textile dyeing industry

3.1. PEST analysis

The PEST acronym stands for the Political, Economic, Social and Technological issues that may affect the strategic development of a business. Identifying PEST influences is a useful way of summarizing the external environment in which a business operates. The PEST analysis is a tool that allows the exploration of the study scenario, which analyses the variables involved and allows a strategic planning for the sector [39].

3.2. Issues of political nature

Portugal is a country with limited endogenous energy resources, particularly those which provide the majority of energy needs. The consumption of fossil fuels in Portugal requires an import of fossil fuels, so that the dependence on foreign energy has a very significant weight in the national balance of payments.

The scarcity of fossil resources leads to a high dependence on foreign energy, especially imports of primary sources of fossil origin. Imports of energy products has a global strategic nature, influencing policies and external positional alignments and relationships with the producing countries of these resources, in a position of strong dependence and always unfavourable.

The replacement of an imported energy source for one of domestic origin just by itself comes to counteract this external dependence, being the resource managed internally by creating a development plan for the forestry sector, for example, safeguarding the energy needs and resource sustainability, in a way that bridge efficiently the one who is intended to replace.

These developments of forestry plans for energy purposes, if performed at a regional scale, allow the supply of local energy needs for industry, demonstrating a policy emphasis on the reindustrialization of the country, particularly in this sector, contributing significantly to the creation of direct jobs in forest management and at energy products supply to consuming companies.

Thus, the political decision of showing the way, for example by applying incentive tax rates for participating companies, allows creating conditions for national companies to compete with their counterparts in countries where, for example, the hand labour is cheaper or are closer to the sources of raw materials.

The policy implication of replacing traditional fossil fuels by biomass use also occurs in the need that the country has to meet its target goals for reducing emissions of greenhouse gases and meeting the goals set by the European Union for the incorporation of renewable energy sources in the coming years.

The environmental advantages are great because the use of biomass as a solid fuel for combustion will contribute to reducing CO₂ emissions to the atmosphere when compared with the use of fossil fuels.

In this perspective, the use of biomass is anticipated as an important measure and should be examined by political entities, since a measure seemingly simple, may have structural implications for the economic fabric of the country, interfering directly in the balance of trade, in job creation, in the reindustrialization of companies, in the development of new business and increasing business competitiveness.

3.3. Issues of economic nature

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

This energy products market designed to provide continuous and permanent power to the industrial sector in question, allows itself the sustainability of the forestry sector developed for the purpose, since the amounts involved to the full satisfaction of the needs of a textile dyeing company with a 8 tons/hour steam boiler is about 8000 tons/year of wood chips with a market value of €600,000.00, as shown in Table 1. This Table also presents the estimated consumption of wood pellets for the same 8 tons/hour steam boiler, of about 5000 tons/year of wood pellets, with a market value of approximately €725,000.00 [35].

See Table 1 at the end of the manuscript.

The development of an energy devoted forestry sector involves jobs creation, promoting and boosting the local economy, and contributing significantly to the promotion of an endogenous renewable natural resource, while creating conditions for the settlement of populations in rural areas and combating land abandonment.

The demand for biomass may even involve the need to increase the existing forest area, promoting the recovery of derelict land. Thus it is expected that forest management with the objective of energy products supply will allow better control of the forest, for example, preventing forest fires, reducing damages annually.

The replacement of traditional fossil fuels by biomass, produces practical effect on direct savings estimated between 18% and 27% in the energy costs of textile dyeing companies [35].

Table 2 presents the estimated average consumption in this type of companies, as well as the savings calculated for current market values.

See Table 2 at the end of the manuscript.

The replacement of traditional fossil fuels by biomass requires that companies undertake changes, or even full replacement of equipment, leading to investment [35]. Table 3 shows an estimation of the required investment.

See Table 3 at the end of the manuscript.

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

3.4. Issues of social nature

The replacement of fuels traditionally used in the Portuguese textile dyeing industry for biomass entails important aspects of social nature particularly with regard to job creation through the development of a devoted forest industry, as well as the setting of the population in rural areas, avoiding movements in search of work to urban centres.

In the industry itself, the use of an alternative that, as seen in the previous section, produces significant savings in energy costs will increase the competitiveness of companies, with the reduction of production costs.

The adoption of environmentally friendly policies by a company transmits to the community where it is inserted an image of responsibility and of concern with the social relationship, creating ties of recognition and improvement of relationships, that neither always are easy.

Textile dyeing companies have traditionally continuous periods of operation, including weekends, causing troublesome due to noise, especially at night-time, as well as the production of liquid effluents and gaseous emissions. As an example, the combustion of biomass instead of natural gas corresponds to CO₂ emissions 26 times lower, which represents a saving of 450 kg CO₂/ton of fuel [40-41].

The adoption of measures recognized as being environmentally friendly and their disclosure to the community, can contribute to a reduction of conflicts and an approach of all parties, since companies must be integrated and be a key part of the communities where they operate.

3.5. Issues of technological nature

Replacing a fuel by other involves aspects of technological nature, referred to the properties of the fuels themselves, especially their physical state, their calorific value, the characteristics of its combustion, the logistics of supply and how they are stored. These aspects influence in a decisive way the feasibility of the proposed intentions of the replacement of any fossil fuel traditionally used in the Portuguese dyeing industry for biomass.

For example, natural gas does not require storage tanks because the national network of natural gas supply directly to the company, while propane and naphtha have to be stored in tanks to feed the burner of the boiler. Biomass must also be stored in the structure created for this purpose, and that can be a silo or a system of moving floor placed in a lower level.

While natural gas does not involve any logistical operation, all others require a schedule for deliveries of fuel and an estimated daily intake to calculate a safety stock in the company, to ensure that fuel will never run out.

Technologies used for the combustion of liquid or gaseous fuels are very similar, for that the use of a boiler with a type of gaseous or liquid fuel is only dependent on the substitution of the burner and small adjustments, while in the case of biomass, in any of its forms, requires the full conversion of the boiler, and in most cases the only option passes right for the total replacement of the boiler. Figures 4 and 5 show examples of biomass burners (wood chips and wood pellets) installed in steam boilers.

See Fig. 4 at the end of the manuscript.

See Fig. 5 at the end of the manuscript.

The gaseous and liquid fuels are provided obeying quality control and characteristics, so that the client receives information about the properties of the products, which tend to be homogeneous over time. Biomass, due to their intrinsic properties, presents greater temporal variability, especially its moisture content, a factor that directly influences the heating value.

The technology required for the combustion of biomass exists for many years in Portugal, and a number of national manufacturers of boilers and accessories have been identified, namely control systems for gaseous and particles emissions to the atmosphere, which have excellent quality/price ratio when compared with other competing European countries.

Thus, contrary to what happens with the burners for liquid and gaseous fuels, which are not manufactured in Portugal, the biomass burners are fully Portuguese technology, it is not therefore necessary to carry out any kind of import.

4. Conclusions

Energy is assumed as a fundamental paradigm for the reindustrialization of the Portuguese industry, namely in the sector of textile dyeing, since it is a major consumer of primary energy. From the analysis it can be seen that the substitution of fuels traditionally used in this industry brings numerous advantages, particularly in aspects related to:

- Increasing the competitiveness of the companies in relation to their counter parts from countries with resources of cheaper manpower or closer to sources of raw materials;
- The creation and preservation of jobs;
- Development of new business areas related to the supply of energy products;
- Enhancement of an endogenous resource, while contributing to the decline in imports of energy products;
- The valuation of rural and forest areas, contributing to the establishment of populations;
- The adoption of environmentally friendly measures and contributing to reducing emissions of greenhouse gases;
- The reduction of energy costs due to the use of a cheaper fuel (18 to 27%, depending on the use of wood pellets or woodchips);
- The use of national technology;
- The contribution to the energy independence from abroad by means of promotion of a national renewable natural resource.

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Figures



Fig. 1. Natural gas burner in a steam boiler.



Fig. 2. Propane gas burner in a steam boiler.



Fig. 3. Naphtha burner in a steam boiler.



Fig. 4. Biomass burner in a steam boiler using wood pellets.



Fig. 5. Biomass burner in a thermal oil boiler using wood chips.

Tables

Table 1.

Estimated Annual Average Values of Woodchips and Wood Pellets Consumption [28]

Woodchips Consumption	Monthly Average	Annual Average (11 months)
kg consumption on steam production (60% of total energy consumption)	750,000.00kg	8,000,000.00 kg
Steam production costs	56,000.00 €	600,000.00 €
kWh Cost	0.027 €/kWh	

Wood Pellets Consumption	Monthly Average	Annual Average (11 months)
kg consumption on steam production (60% of total energy consumption)	450,000.00 kg	5,000,000,00 kg
Steam production costs	65,000.00 €	725,000.00 €
kWh Cost	0.030 €/kWh	

Table 2.

Annual Total Savings when using Biomass instead of Natural Gas [28]

	Pine Woodchips	Wood Pellets
Annual steam production costs	600,000.00 €	700,000.00 €
Annual total savings	27 %	18 %

Table 3.

Investment needs for the replacement of steam boilers [28]

Steam Production Boiler capacity (t/h)	Investment (€)
5	350,000.00 €
10	700,000.00 €
15	1,000,000.00 €