INITIAL SURVEY OF THERMAL AND ELECTRICAL ENERGY CONSUMPTION IN BRAZILIAN CERAMIC TILE INDUSTRY

Helton José Alves, Fábio Gomes Melchiades and
Anselmo Ortega Boschi*

UFSCar – Federal University of São Carlos
DEMa – Department of Materials Engineering
LaRC – Laboratory of Ceramic Tiles
Rod. Washington Luiz, km 235, 13565-905 São Carlos, SP, Brazil
*e-mail: daob@power.ufscar.br

Abstract: This work presents some of the main results obtained in an initial survey of the energy consumption and costs involved in the ceramic tile manufacture in Brazil. Despite the fact that the high mean of the energy cost on the total cost of the ceramic tile manufacture, until the present moment, there is no specific study in this sector intending to quantify the industries' energy consumption and to relate it to the particularities of their productive processes. The results obtained through the measurement of thermal and electrical energy consumption in each part of the manufacture process by dry route of a Brazilian industry are presented here. These results are compared to the energy consumption presented by Brazilian industries which use the wet route process as well as to the data about the consumption of Italian ceramic tile industries. Moreover, the importance of these data survey to make strategic decisions to assure the competitiveness of Brazilian ceramic tile industries is highlighted.

Key words: energy consumption, energy survey, natural gas, electrical energy, dry route, wet route.

1. Introduction

Although it is a common sense that the expenses with thermal and electrical energy represent a considerable part of tiles production cost, there is no detailed research data about this theme in Brazilian ceramic tile industry. Without trusting and systematically collected information (history) about the energy consumption of each equipment, it is impossible to make decisions to increase the energetic efficiency and consequently to reduce the production costs.

The reduction of the energy consumption of an industry can result as in a reduction of cost, due to a smaller amount of energy required, as in a gain in productivity, when it is in the industry's interests to keep the amount of energy contracted, taking advantage of the "quantity" of energy which would be "saved" to expand the production investing in new equipment or increasing the number of production lines.

Besides the routine administration of an installed industry, the knowledge about the energy cost is fundamental to make decisions about production expansions, new equipment and even new plants or companies.

In this way, considering the size of Brazilian ceramic tile industry, the fact that the market has become more competitive each day and any reduction in production cost can represent gains in terms of competitiveness, it is fundamental that this theme receive more attention urgently.

Besides economic aspects, the energetic factor is close related to the environment and, invariably, the energetic efficiency improvement involves environment gains.

In this context, the objective of this work was to do an initial survey of the energetic aspects related to the Brazilian ceramic tile industry. More specifically, considering that the ceramic tiles are produced through two different routes in Brazil, the wet and dry ones, this survey intends to collect data to answer the following questions:

- Which is the difference of the energy cost between dry route and wet route?

- How can the energy consumption of Brazilian wet route be compared to European one?
- How is the energetic consumption distributed along each part of the productive process?

2. The Brazilian dry route

A particular characteristic of Brazilian ceramic tile sector is that the industries use two different processing routes to manufacture their products: “wet route” and “dry route”. Nowadays, about 65% of national production is manufactured using dry route [1]. The Brazilian ceramic poles are concentrated in two regions: Criciúma (Santa Catarina) and Santa Gertrudes (São Paulo), being the majority of the industries which use dry route located in Santa Gertrudes region. The products obtained by dry route, in general, are enameled ceramic plates which present water absorption between 6 and 10% and base with red as firing color. The processing of the material through dry route is characterized by the preparation of a batch by dry milling (~5% of damp - which dispenses the atomizer), pressing (~9% of damp) and fast single firing (20-30 min).

The dry route batch stands out because it presents a typical composition and by the mean that it is milled. Generally, the batch consists in only one raw material naturally constituted by the necessary proportions of the minerals which allows the manufacture of the wanted products. The batch consists of only one clay, or sometimes, by the mixture of many types of clay. The crude clay extracted from natural deposits (in blocks) is carried by trucks and transported to the natural drying in specific places, where the reduction of damp (values next to 5%), the homogenization and the primary crushing occur. After this work, the material follows to the milling.

At the dry milling, the raw material is firstly comminuted in the primary mill (hammer mill), and then, the hard fraction that was not milled is transported to the secondary mill (pendular mill). The resultant powder is wetted (~9%) and granulated.

The following parts of the process are practically identical to that of the wet route.

3. Usage of energy in ceramic tile industries

The ceramic tiles processing requires a high energy consumption that reflects effectively in the production costs composition. It is known that, in Italy, the expenses with energy represent about 23% of the total cost of production, becoming evident that energy cost has great influence on the price of the final product [2].

Figure 1 illustrates the processing stages used by wet route industries and the types of energy used in each part of it. In a general way, the products processing by wet route is different from dry route mainly because of the milling stage, meaning: in dry route water is not used, dispensing the presence of the atomizer. Figure 1 can also represent the productive process of dry route when the atomization stage is excluded.

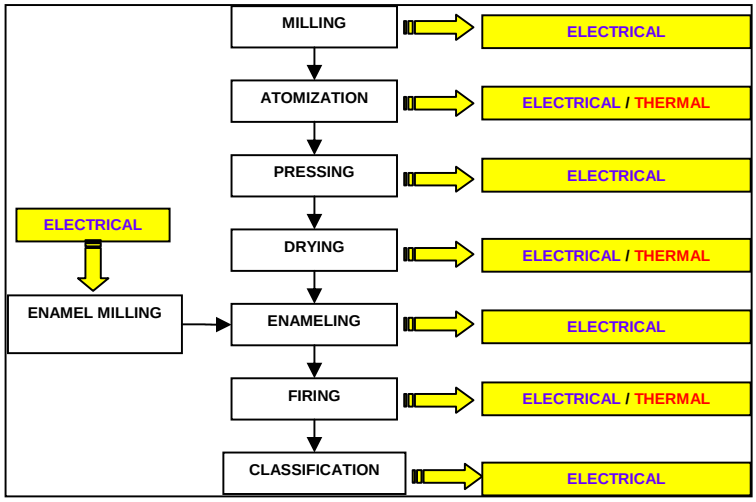

Figure 1 - Ceramic tile processing stages by wet route and the kinds of energy used in each stage.

3.1 The energy consumption evolution

The evolution of the thermal and electrical energy consumption in the ceramic tile sector in the last decades can be observed by the increase in the world production. Among the few publications about this theme, a survey made in the Spanish ceramic tile sector deserves to be highlighted, and it can observed in Figure 2, that in one decade the consumption of electrical and thermal energy increased four times, practically. In this same period, the production of tiles in Spain increased almost three times [3].

It is important to point out that Spanish production has continued to increase progressively in this last decade, overcoming 400 millions of square-meters in 1995 to 648 millions of square-meters in 2005.

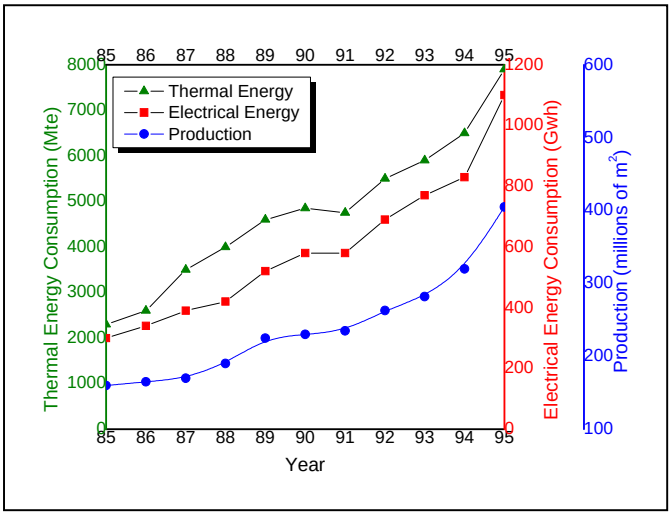

Figure 2 – Evolution of energy consumption and the Spanish ceramic tile production [3].

3.1.1 Natural gas

Nowadays, the natural gas is the main source of thermal energy used by the ceramic tiles industry in the world. The stages of ceramic material processing that need heat, in order to that all physic-chemical transformations happen, are: atomization (wet route), drying and firing. In Brazilian scenary, São Paulo state is the biggest national producer of ceramic tiles where more than 60% of the industries of this sector are concentrated. The participation of natural gas consumption in the ceramic sector on the total volume that is commercialized inside the state represents 16% [4], being in the second place, and standing behind of the chemical/petrochemical industry, according to the Figure 3.

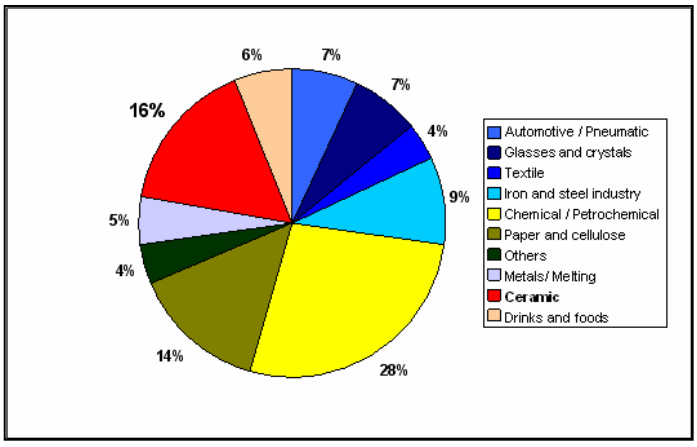

Figure 3 – Participation of the different sectors in the natural gas consumption in São Paulo State [4].

The major part of the energy cost of ceramic tile industry can be attributed to the natural gas. This is the reason why the industries search alternatives to increase their efficiency, reducing consumption and

increasing productivity.

4. Survey of energy consumption and cost

Two kinds of work were made simultaneously: the first one is a detailed survey of the thermal and electrical consumption of a dry route industry, in which an analysis of the energy cost presented by the same was also done; in the second work a comparison between the thermal consumption and the energy cost of some dry and wet route industries was done. In the following items, the activities related to the development of each work are separately detailed.

4.1 Energy survey in a dry route company

The industry where the survey was done is located at the productive pole of Santa Gertrudes – SP and it produces enameled tiles of BIIb kind, with a nominal shape 43 x 43 cm and thickness of 8,6 mm. This industry did not have any indicative of specific consumption of the consuming equipment and the main objective was to determine it through direct measurement.

The electrical energy consumption measurements were done in "energy panels" (where the conducting cables pass by) that come before the energy entry in each consuming equipment. So that, ammeter tweezers and multimeters were used, being necessary subsequent corrections and conversions of the obtained values.

The measurements of thermal energy consumption (natural gas) were done through readings of consumed gas volume in a determined interval, being also necessary to know pressure and temperature values at points in the tubes before the gas entry in dryers and kilns. The observed values for the volume were corrected through normalization, so that all the measures could be comparable [5].

Three daily measurements were made at different times during a month, what was necessary to have a follow on the industry average consumption in a bigger interval, making the results more reliable and representative.

The next step was to convert the values of electrical energy consumption, first obtained in kWh, and the values of natural gas consumption in m^3/day, to only one unity: kcal/kg of fired product. So that, it was possible to compare the electrical consumption to the thermal consumption, and yet, it was obtained a value for the total consumption by means of the two kinds of energy addition. The unity kcal/kg allows comparing the consumption among industries which manufacture products with different characteristics, varied typology and also with those which manufacture products by distinct routes, as dry and wet routes.

A cost analysis based in taxes determined by the concessionaries that supplied São Paulo state in the period that the measurements were done (September/2006) was also made. So that, the participation of each energy kind on the global energy cost of the industry was determined as well as how the costs with energy act on the square-meter of final product total cost.

4.2 Comparison between dry route and wet route

Many Brazilian industries of dry and wet route that manufacture products with 43 x 43 cm shape, BIIb kind (which is the typology produced by the industry analyzed in item 3.1) were contacted, intending to know the values of natural gas consumption of dryers, kilns and atomizers (wet route) that they made available. Then, it was possible to make a comparative table, in which each equipment consumption and total thermal consumption could be compared among the industries.

5 Results and discussion

The following results refer to the consumption measures done in the industry described in item 4.1. Figure 4 presents the results of the electrical energy consumption (in %), divided in the industry sectors.

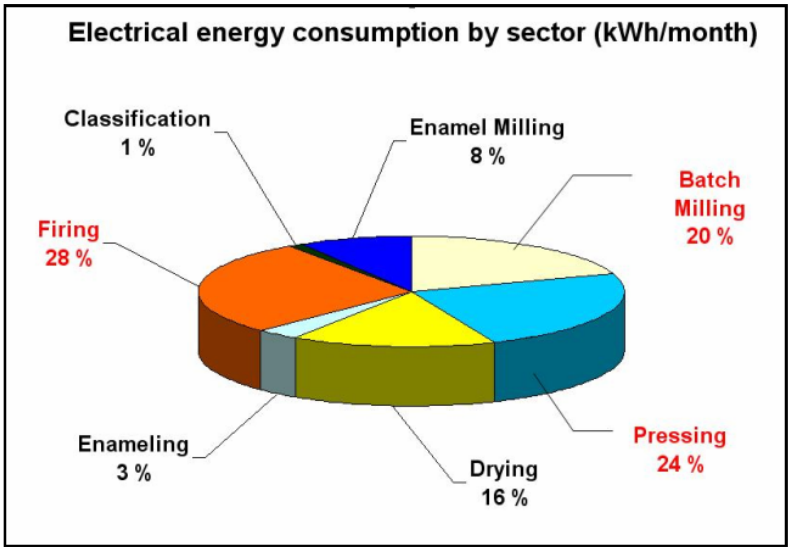

Figure 4. Distribution of electrical energy consumption by sectors.

It is observed that 28% of electrical energy consumption of the analyzed industry is associated to the firing step, in which the kilns and lungs are included. The consumption of electrical energy in the pressing and batch milling steps (mills, vibrate sieves, elevators, conveyor belt and granulator) is also expressive because they are in the second and third place, respectively, in the total of consumed electricity. It is important to point out that the errors associated to the measures along the period of measuring were small for practically all the equipment.

Figure 5 shows the drying and firing steps percentages' participation on the thermal energy consumption. It was possible to observe that the consumption of the firing step represents about 80% of the total natural gas consumed by the industry, in other words, the consumption of the kilns reaches values up to four times bigger than those presented by the dryers.

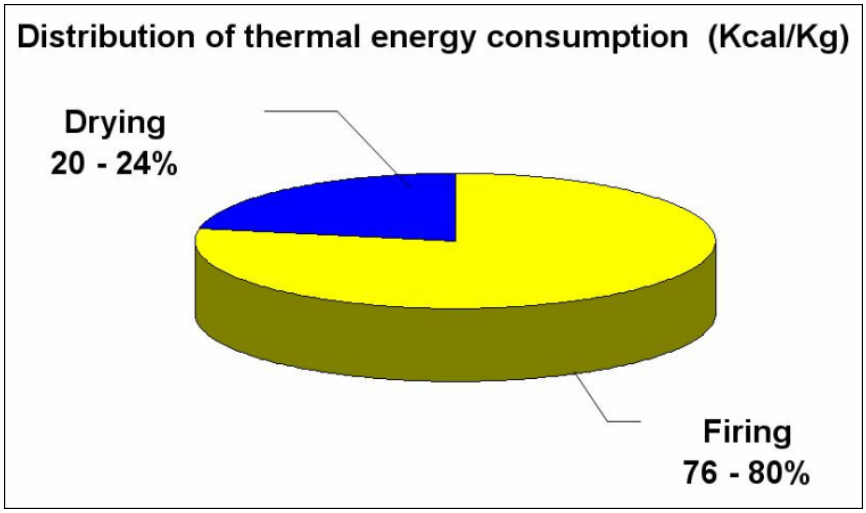

Figure 5 – Distribution of thermal energy consumption by sectors.

After the conversion of all obtained results to only one unity, kcal/kg of fired product, it was possible to accomplish totalized values of energy consumption (electrical + thermal), as can be observed in Table 1.

Table 1 – Global values of energy consumption in kcal/kg of fired products.

Processing steps	Energy consumption (kcal/kg)		
	Electrical	Thermal	Total
Batch milling	10,15	-	10,15
Pressing	10,12	-	10,12
Drying	6,67	117,50	124,17
Enameling	1,46	-	1,46
Firing	11,91	420,00	431,91
Classification	0,40	-	0,40
Enamel milling	3,70	-	3,70
TOTAL	**44,41**	**537,50**	**581,91**

Making a balance of the industry global thermal consumption, it is possible to say that the energy consumption involved in ceramic tiles production is about 582 kcal/kg, as seen in Table 1. In this way, it was calculated the participation of each sector's average consumption over the industry global consumption (Figure 6). The drying and firing sectors together are responsible for 95,5% of the total energy consumption. The pressing and batch milling sectors appear in third and fourth places, presenting a small participation (1,7%) over the total energy consumption. In turn, the other sectors (enamel milling, enameling and classification) present very low energy consumption when compared to the values presented by other steps.

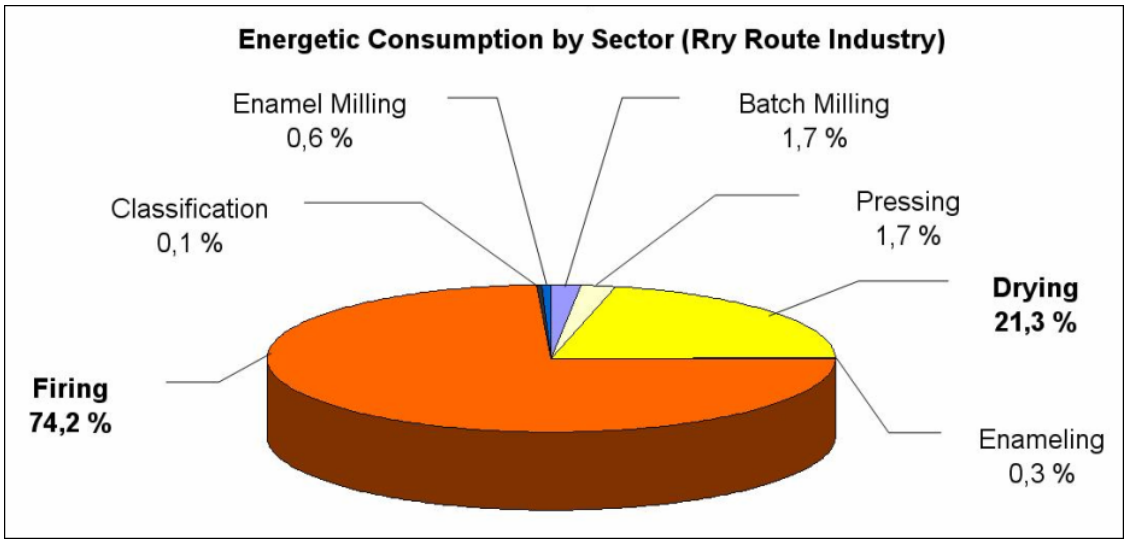

Figure 6. Distribution of global energy consumption by sector.

Considering the values of Table 1, it is possible to say that electrical consumption represents only 8% of the industry global energy consumption, as seen in Figure 7. However, when the participation of electrical consumption over the energy cost is calculated, it is possible to note that it reaches 22% (Figure 8), what makes evident the high cost of electrical energy paid by the industry.

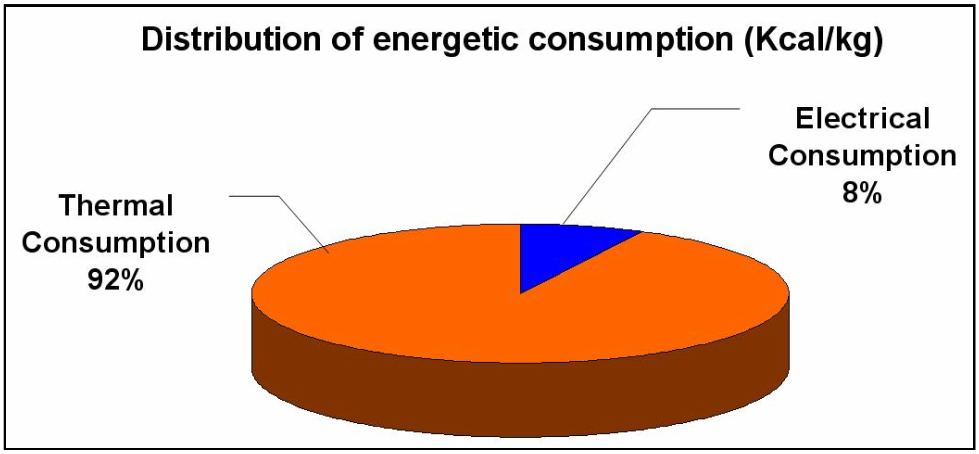

Figure 7. Participation of electrical and thermal consumption over the total energy cost.

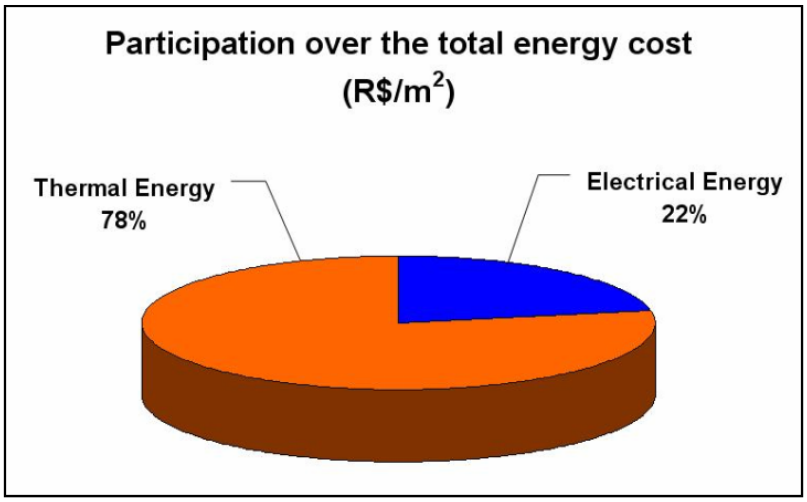

Figure 8. Participation of thermal and electrical consumption over the total energy cost.

Table 2 presents the values of natural gas average consumption of kilns, dryers and atomizers (wet route), given by many of dry and wet route Brazilian industries (item 4.2). It is important to point out that this data was given by the industries; therefore, the methodology applied at the previous case was not applied for all the industries. However, these values can be an indicative that really exist great consumption differences among the industries of this sector.

Table 2 – Thermal consumption of the equipment used by dry and wet route industries.

INDUSTRY	**TECHNOLOGY**	**AVERAGE THERMAL CONSUMPTION (kcal/kg)**			
		Kilns	**Dryers**	**Atomizers**	**Total**
A	Wet	593	172	418	1183
B	Wet	455	105	330	890
C	Wet	520	150	365	1035
D*	Wet	450	---	---	1050
E	**Dry**	**420**	**118**	---	**538**
F	Dry	411	149	---	560
G	Dry	464	196	---	660
H	Dry	415	175	---	590

* this industry did not give the values of dryers and atomizers consumption.

It can be noted in Table 2 that there are great differences among the values of total thermal consumption, as inside the group of industries that use the same processing route as between the dry and wet route. In the first case, it is possible to observe some considerable variations in the consumption presented by the kilns, dryers and atomizers, mainly between the industries A and B (wet route), resulting in a difference of 293 kcal/kg between the total consumption of the two industries. It is also important to point out the difference of 122 kcal/kg observed between the industries E and G (dry route). In the second case, it could be observed that wet industries thermal consumption (A, B, C, and D) is much bigger (up to two times) than the presented by the dry route ones (E, F, G, and H), mainly because of the atomizer presence, used in the wet route processing. The industry named as E in Table 2 is the same of the one where consumption measurements presented at the beginning of this item were done, and also this same industry was pointed out by having the lowest consumption.

Table 3 has the published data about the average thermal consumption of the equipment used in the production of tiles with white and red firing color base by Italian wet route [5]. It is valid to point out that this data is a reflex of a survey done in Italy with 230 dryers, 200 kilns, and 40 atomizers, what makes evident the results trust. It can be observed in Table 3 that the values obtained from dryers and kilns of industries which produce white base tiles are similar to the red base, however, the average consumption of the atomizers is very different.

When the values of Table 2 and 3 are compared, it can be noted that the total thermal consumption of Brazilian wet route industry can be considered similar to the Italian wet route, because the values presented in Table 3 are an average, and can have errors in them. However, without considering the errors, what is observed is that the Italian dryers consumption is, in general, lower than the Brazilian ones. On the other hand, the consumption of the Italian kilns is much higher than the Brazilian ones.

Table 3 – Thermal consumption of equipment in Italian wet route industry' .

BASE	**AVERAGE THERMAL CONSUMPTION (kcal/kg)**			
	Kilns	**Dryers**	**Atomizers**	**Total**
White	627	107	312	1046
Red	693	99	478	1270

In Figure 9 it is illustrated an estimative of average cost in R$, according to the energy consumption in kcal/kg presented by Brazilian industries. For this estimative realization, a production of 2.000.000 m^2/month and an equal ratio of 17 kg/m^2 of fired product was fixed as a parameter to the calculations. Analyzing the graphic in Figure 9, it is possible to observe that a difference in the consumption of 100 kcal/kg can represent a value about R$290.000,00/month paid by the industry. This exemplified difference can be observed even inside the same industry, for example, similar equipment of different production lines that present big consumption differences between themselves.

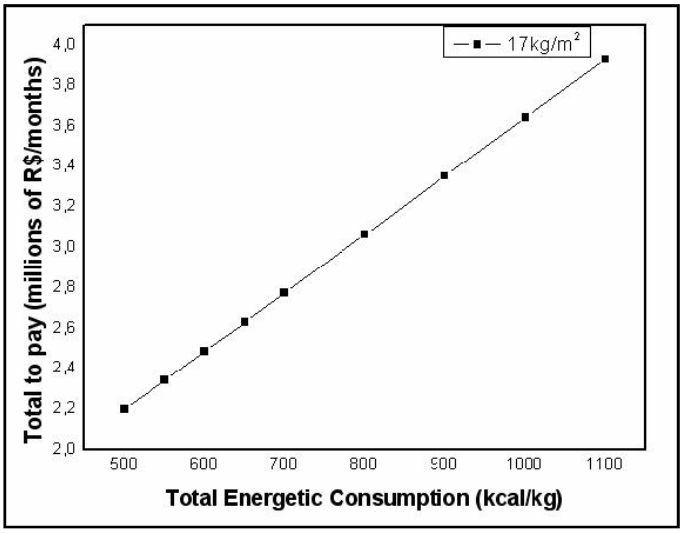

Figure 9. Variation of energy cost according to the variation of total energy consumption.

Comparing the data of average thermal consumption of the dry route industries to the wet route ones (Table 2), and using the graphic presented in Figure 9, it is noted that the difference among them can reach values up to 645 kcal/kg. This implies in a cost increase of wet route in relation to the dry route (considering only the natural gas consumption) up to R$ 1.900.000,00/month.

6 Final Comments

Considering the given results, it is possible to make the following comments:

- in general, related to the energetic aspects, the dry route is much cheaper than the wet route;
- Brazilian wet route is similar to the Italian in the values of total thermal consumption, however, it has, apparently, a lower kiln consumption;
- the productive process steps (at the analyzed dry route industry) that consume more energy are firing and drying, with 74,2% and 21,3% of participation over the total consumption, respectively. The remaining consumed energy, 4,5% of the total, is distributed among the other production steps.

A detailed knowledge about the consumption of each equipment or each productive process' stage allows indicating what is (are) the main responsible(s) for the total consumption presented by the industry. When analyzing the consumption differences among the industries, some characteristics of the analyzed equipment can also be considered, like: manufacturers, dimensions and operation conditions. Through this knowledge, it is possible to make an energetic management, and important actions like consumption reduction by means of equipment adjustment or buying/changing them can be better planned, reflecting in a possible reduction of expenses with energy.

The results presented here are an initial data of an energetic survey that will include a bigger number of tile industries, subsequently. As it is an initial survey, the data does not necessarily represent the whole sector; however it indicates a possible real discrepancy among thermal consumption of its industries. In the future, other more complete works will be published, and it is expected that it can be possible to draw an energy profile of Brazilian ceramic tile industry. For this achievement, the participation and opening of industries to the realization of this kind of work are fundamentally important.

7 References

[1] ANFACER – Associação Nacional de Fabricantes de Cerâmica de Revestimento. Available in: http://www.anfacer.org.br/. Date: 14/08/2007.

[2] Crasta, G. P. Costi e ricavi dell'industria ceramica italiana. **Ceramic World**, v.16, n.65, p.46-50, 2006.

[3] Enrique, J. E., et al. Evolución de los consumos de energía térmica y eléctrica en el sector de baldosas cerámicas. **Técnica cerámica**, n.246, España, 2006.

[4] Comgás – Companhia de Gás de São Paulo. Available in: http://www.comgas.com.br/. Date: 25/08/2007.

[5] Nassetti, G., et al. **Piastrelle Ceramiche & Energia**. p. 20, 109-113, Centro Ceramico, Bologna, Itália, 1998.