CASE STUDY ON THE USE OF QUALITY MANAGEMENT TOOLS IN IMPROVING BIOMASS-FIRED BOILERS

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Abstract—Globally, energy consumption has constantly increased in the last decades. The production and sale of biomass-fired boilers have considerably gone up in Romania. Considering the increasingly fierce competition in this field, this paper puts forward the use of established quality management methods and techniques in order to improve biomass-fired boilers. The case study has been made for an SME (small- and medium-sized enterprise) in Sibiu, Romania.

Keywords—biomass, costs, customer, heating.

I. INTRODUCTION

The beginning of the 21st century was marked by a great energetic challenge. Globally, energy consumption has constantly increased, yet reserves of hydrocarbons are only available for a few decades and are concentrated in just a few countries. The import of energetic resources is constantly growing in many countries, and so are the economic and political risks it engenders.

On the other hand, the emissions of greenhouse gasses are increasing, too, mainly as a result of the burning of fossil fuels. Soil and water are more and more polluted, and, consequently, they turn into more and more serious threats to human health and to the possibility of irreversible climate change on Earth. All these have been strong reasons for making and promoting global, European and national decisions directed towards the implementation of renewable sources of energy—solar, wind-powered, hydraulic, biomass-fired, etc. – as environmentally friendly sources.

In this context, the production and sale of biomass-fired boilers have considerably gone up in Romania[2]. Considering the increasingly fierce competition in this field, this paper puts forward the use of established quality management methods and techniques in order to improve biomass-fired boilers. The case study has been made for an SME (small- and medium-sized enterprise) in Sibiu, which we have called TERMA Ltd. The names of the companies referred to in this paper are all fictitious.

II. CASE STUDY

The QFD (Quality Function Deployment) analysis shows an organizational environment conducive to the manufacturing of better products at lower costs. The method involves building a “Quality House” in order to organize the processes of product design and manufacturing into more detailed levels.

For the new product to be competitive on the market, we must meet, by appraising the technical feasibility and economic efficiency, the customers’ expectations and requirements. For this, we have carried out a detailed market analysis and compiled a customer questionnaire.

Table I shows the comparative costs of the old and newly proposed products, recorded by one of the customers, who owns both heating systems (with similar requirements. For this, we have carried out a detailed manufacturing into into more detailed levels.

Table I shows the comparative costs of the old and newly proposed products, recorded by one of the customers, who owns both heating systems (with similar characteristics) in different locations in Romania. That client of TERMA Ltd. has provided us data in the table I.

TABLE I

<table>
<thead>
<tr>
<th>Product</th>
<th>Fuel type</th>
<th>Unit (£/Euro)</th>
<th>Initial costs</th>
<th>Annual maintenance costs</th>
<th>Annual fuel costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old</td>
<td>Liquid Fuel</td>
<td>10' (£)</td>
<td>11</td>
<td>0.9</td>
<td>11.9</td>
</tr>
<tr>
<td>Old</td>
<td>Methane</td>
<td>10' (£)</td>
<td>12</td>
<td>0.7</td>
<td>17.8</td>
</tr>
<tr>
<td>New</td>
<td>Wood Chips</td>
<td>10' (£)</td>
<td>16</td>
<td>0.4</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Table II presents several fuel prices.

For a building of 800 m² with a high of 6 m and a heating system of 240 kW, we have summarized in Table III the calculated results in the case of four alternative types of fuels. To heat up 1 m³ of water from 10°C to 55°C we need the energy Q (in MJ = 10⁶ J):

\[ Q = 4185(\text{J/kg/°C}) \times 1000(\text{kg}) \times 45(\text{°C}) = 188.3 (\text{MJ}) \]
So, we used the value obtained in relation (1) in the calculation made in table III. For the marketing research, we eliminated the most expensive variant of the boiler, those with electricity.

III. THE BENCHMARKING AND THE QUALITY HOUSE

Following the marketing research, we identified the customers’ requirements with regard to the product and the importance of the required characteristics.

Benchmarking is the method and/or process by means of which one can determine (through quantification) who is the best in a field, which sets the standards and in what this standard consists ([4], p. 87).

After centralizing the marketing research results, we selected from product functions the most requested by customers and thus, technical benchmarking was performed. Its results as those of its two stronger competitors – ALFA and BETA – meet their requirements; thus, the so-called “client benchmarking” was performed. The scores given by clients are centralized in Table V. In order to follow the methodology for building the Quality House, we rounded the averages obtained from customer opinions to the used scale values: 1, 2, 3, 4, or 5.

The products of the company were tested as well. The technical data were determined for the three products; thus, technical benchmarking was performed. Its results are presented in Table VI.

The scale was: 1 point for a “very unimportant” characteristic, 2 points for “important”, 3 for “neutral”, 4 for “important” and 5 for “very important”.

The questionnaires were designed in order to enable customers to point out how the TERMA products as well as those of its two stronger competitors – ALFA and BETA – meet their requirements; thus, the so-called “client benchmarking” was performed. The scores given by clients are centralized in Table V.

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Considering these data, we obtain the QFD matrix (Fig. 1).
be taken by TERMA ltd.:

1) Reducing the initial costs of the investment: adopting a strategy of product renewal, the target market segment consisting of companies that already have their own heating system, to which a boiler with wood chips and the other parts of a biomass-fired central heating system can be accommodated while preserving district heating and existing facilities.

2) Reducing fuel storage and transportation costs: another category of customers targeted by TERMA Ltd. includes companies belonging to the wood processing industry, where the production process generates wood

![QFD Matrix](image)

**PRODUCT CHARACTERISTICS**

| Customer Requirements | Importance of Customer Requirement | Conducive model/Fuel storage | Level of CO₂ emissions | Environmental hazards caused by fuel transportation | Expenses for fuel storage and transportation | Yield [%] | Type of fuel supply | Investment costs of 2-40 kW central heating | Annual maintenance costs | Overall dimensions | Weight [kg] | TERMA | ALFA | BETA | Objectives for products improvements (maximum of score) |
|-----------------------|----------------------------------|-----------------------------|------------------------|---------------------------------------------------|-------------------------------------------|----------|-------------------|---------------------------------|------------------------|----------------|---------|--------|--------|----------------------------------------------------------|
| ... heat quickly       | 4                                | 3                           | 0                      | 0                                                 | 9                                         | 0        | 1                 | 0                              | 0                      | 3             | 0       | 2      | 4      | 5                                                        |
| ... have easy access to fuel | 4                            | 3                           | 0                      | 0                                                 | 9                                         | 1        | 0                 | 0                              | 0                      | 3             | 1       | 2      | 4      | 3                                                        |
| work with cheap fuel  | 5                                | 0                           | 0                      | 0                                                 | 1                                         | 0        | 1                 | 0                              | 3                      | 9             | 0       | 5      | 2      | 3                                                        |
| ... not pollute       | 3                                | 1                           | 9                      | 3                                                 | 0                                         | 0        | 0                 | 0                              | 0                      | 0             | 0       | 5      | 3      | 2                                                        |
| ... have a short investment payback period | 4                             | 0                           | 1                      | 0                                                 | 0                                         | 0        | 9                 | 1                              | 0                      | 0             | 0       | 5      | 4      | 3                                                        |
| ... work safely       | 5                                | 1                           | 3                      | 1                                                 | 0                                         | 0        | 3                 | 0                              | 0                      | 0             | 0       | 5      | 3      | 2                                                        |

**IMPORTANCE OF PRODUCT CHARACTERISTICS**

<table>
<thead>
<tr>
<th>TERMA</th>
<th>ALFA</th>
<th>BETA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot water boiler/ Wood Chips</td>
<td>Hot water boiler/ Medium</td>
<td>Hot water boiler/ Black Oil</td>
</tr>
<tr>
<td>Baseline</td>
<td>20 times</td>
<td>30 times</td>
</tr>
<tr>
<td>Low</td>
<td>Average</td>
<td>High</td>
</tr>
<tr>
<td>85</td>
<td>Average</td>
<td>80</td>
</tr>
<tr>
<td>16000 €</td>
<td>12000 €</td>
<td>11000 €</td>
</tr>
<tr>
<td>400 €</td>
<td>700 €</td>
<td>900 €</td>
</tr>
<tr>
<td>1.21 €/kg</td>
<td>2.33 €/m³</td>
<td>5.08 €/l</td>
</tr>
<tr>
<td>1.0m³/0.8m³/1.5m³</td>
<td>1.0m³/0.8m³/1.5m³</td>
<td>1.0m³/0.8m³/1.5m³</td>
</tr>
<tr>
<td>45 kg</td>
<td>45 kg</td>
<td>45 kg</td>
</tr>
</tbody>
</table>

**TECHNICAL BENCHMARKING**

1) Reducing the initial costs of the investment: adopting a strategy of product renewal, the target market segment consisting of companies that already have their own heating system, to which a boiler with wood chips and the other parts of a biomass-fired central heating system can be accommodated while preserving district heating and existing facilities.

2) Reducing fuel storage and transportation costs: another category of customers targeted by TERMA Ltd. includes companies belonging to the wood processing industry, where the production process generates wood
waste. These companies usually have dedicated facilities (in compliance the laws in force) for the safe storage of waste.

Thus, following these measures, three priority market segments, on which the company will mainly focus its marketing program, take shape (Fig. 2).

3) Expanding on the rest of the industrial market: the product promotion strategy will use, in order to persuade customers, four basic advantages of biomass-fired heating systems:
   a) Cheaper heat;
   b) Immediate environmental benefits;
   c) Long-term climate protection;
   d) Easy access to fuel.

4) Applying the concept of business to business marketing: industrial customers will be provided with biomass-fired heating systems that bring long-term economic benefits. They will be able to build urban or rural heating systems, with short heat networks, to service other utilities (administration buildings, schools, hotels, guesthouses, residential areas, greenhouses, etc.).

5) Using the multiple win situations in the future partnerships: TERMA Ltd. must involve in clusters or networks that develop sustainable projects in the field of efficient use of biomass.

An example of good practice is the intention of partners Corbion, Uniper, RWE and the Port of Rotterdam Authority to establish a biorefinery [5] that will convert wood chips in two categories of products: fuel and feedstock for plastics.

Ethanol will be the fuel obtained in this bio-refinery and lactic acid PLA the feedstock for plastics and other chemical products [5].

Polyactic acid or polylactide (PLA) is a biodegradable thermoplastic aliphatic polyester [6] derived from biomass. Since 2010, it is one of the most used bioplastics of the world [6].

The bio-refinery of the four previously mentioned partners will limit the consumption of fossil combustibles and reduce the CO₂ emissions [5]. Another advantage is the circular shape of the entire process that allows the recycling of all residues [5]. Of course, it is a win situation for each business partner.

This type of partnerships explains why “about 75% of all biofuels consumed in the EU” in 2015 “were produced within the Union” [7].

TERMA Ltd. has to find partners with experience in the use of biomass, in order to design and offer sustainable products for small, medium and large enterprises.

IV. CONCLUSIONS

Because of escalating environmental and climatic disturbances on a planetary scale, caused by modern human activities, the worries expressed by the population and the concern for protecting the natural environment have increased significantly in recent years.

The QFD matrix is an effective technique for the presentation and processing of data structures related to product quality meant to protect the natural environment and extremely useful in production.

REFERENCES


