A Survey and Analysis of Energy Consumption of Industrial Factories within the Central Region of Thailand

Narin Wattanakul and Boonsap Witchayangkoon
Faculty of Engineering
The Thammasat University
Pathumtani 12121, Thailand
Tel. (66-2) 5643001-9 ext 3055
Fax (66-2) 5643010
Email: wnarin@engr.tu.ac.th, wboon@engr.tu.ac.th

Abstract

Energy has an increasing important role not only in our daily life, but also everywhere, particularly in industrial factory where amount of energy is consumed the most. This work is a study of energy consumption of 18 industrial factories related to foods, textiles, chemicals, metals, and woods. All these factories are located within the central region of Thailand. From the study, it is estimated that energy uses by the factories are more than 4 millions kWh/y. This amount is equivalent to raw oil of almost 0.4 millions liters per year or, in monetary term, nearly 4 millions baht per year.

Survey information of each factory is then analyzed for a purpose of energy saving strategy and advice. All information of the study is afterwards sent back to the respective factories for revises, adjustments or improvements of matters related to increase energy efficiency. Many adjustments and revisions can be instantly accomplished; while various level amount of investment is required in some parts to improve the energy efficiency thus provides immediate and relatively predictable positive cash flow resulting from lower energy bills. It is predicted that total energy savings of these factories is more than 1.9 millions kWh/y (14.5%) which in turn saves country's currency 4.3 millions baht per year.

1. Introduction

In developing countries such as Thailand, electric energy is stayed still one of the most basic resources used to operate machines as well as lighting. Further, energy consumption by

a factory can be said to be the most compared to that by a household. Moreover, world's energy as whole is seemed to decrease causing price of energy likely to go further higher every now and then. Furthermore, Thailand water-generated electric energy and other energy sources are very limited. This makes Thailand has imported various kinds of energy producing losses of its currency. Many energy related policies have been announced by government sectors and got well acceptances by the publics all over the country. However, one of the effective methods is to reduce current energy consumption of each individual sector. Many guidelines related to energy survey for building and factory are available from various sources such as [1], [3], [4], [6], and [7] while energy saving for electric transformer and discharge is discussed in [2]. Guideline to lower electrical bill of industrial factory is given in [5].

Before any consumed energy reductions can be made, current energy uses in detail must be studied and analyzed. We have paid attentions to the industrial factory sector in particular. Therefore, a total of eighteen factories are randomly selected from the central region of The Kingdom of Thailand. These industrial factories can be divided into five categories: foods, textiles, chemicals, metal, and woods, as given in Table 1. A survey of energy consumption is then followed as details are given in the following section.

RECEIVED 9 JULY, 2002

ACCEPTED 24 OCTOBER, 2002

Table 1. Audited factories classified according to type of each factory

Categories of factories	Numbers of factories
Foods	2
Metals	7
Textiles	2
Woods	4
Chemicals	3
Total	18

This study concentrates on medium size factories, based on capacity of apparent power less than 1175 kVA.

2. An Energy Consumption Survey of Industrial Factories

After choosing a factory randomly, our staff members will contact the factory manager asking permission for an energy survey. If permission is given, then a survey can normally be started within two weeks. An energy survey consists of electrical energy consumption measurements and heat energy measurements of a factory. In general, all types of energy consumption measurements can be divided into five portions as detailed in the followings.

2.1 Electric Energy Measurements At Factory's Main Distribution Broad (MDB)

MDB is a total electrical supply of a whole factory. A gauge is attached to MDB for continuously measurement of electrical uses in real time for seven days. Then an average electrical consumption can be computed from a seven-day data set. The measurement includes active power, reactive power, apparent power, power factor, voltages and current of three-phase electrical system.

2.2 Electrical Power Measurements at Each Individual Machine

While a three-phase machine is running at full load, both active power and power factor are measured. In addition, nameplate of a machine is also documented. Further, belt's tension of a motor is also measured in percentage of tightness. Furthermore, for each survey an interview with staffs working at the machine is made. The interview question contains of operating hours of each individual machine. Energy consumption information is then classified according to working departments for energy uses comparison.

2.3 Measurements of Air Conditioner Electrical Energy Consumption

Five factors that are related to energy consumption of an air conditioner have been measured. These include measurements of temperature (°c), relative humidity (% RH), wind speed (m/s), active power and power factor. Areas of respective rooms are also measured. Additional, air conditioner using hours must be known by interviewing related personnel for later analysis of energy savings.

2.4 Illumination Measurements of a Factory's Lighting System

According to illumination standard, light-gauging meter is employed to measure illumination (LUX) of the working areas. Also, numbers of lighting are counted through out a factory.

2.5 Boiler Efficiency Parameters Measurements

Boiler's highest working temperature is measured, but not more than 1000°C. Besides, constituents of exhausted smoke from the boiler are gauged including CO, CO_2 and O_2. Further, the boiler working system as well as its heating system is thoroughly examined. After having information of all parameters, a calculation of boiler efficiency can be performed.

3. Schematics of Energy Analysis

Fundamental purpose underlying energy analysis is to find appropriate approach such that energy consumption can be reduced at possible highest rates. Therefore, schematics of energy analysis have been set as given below.

1. Reduction of peak demand

2. Increment of power factor
3. Tap-change transformer
4. Adjustment of motor's belt tension
5. Alteration to use higher efficient motor
6. Variable speed drive on air compressor
7. Application of luminaire refractors and high efficient fluorescent lumiaire to a lighting system
8. Utilization of low watt loss ballast for fluorescent lamps
9. Usage of high frequency electronic ballast for fluorescent lamps
10. Alteration to use high EER type of air conditioners
11. Utilization of electric thermostat controller of air conditioners
12. Maintenance of air conditioners
13. Increase boiler combustion system
14. Alteration to use bunker oil grade C instead of grade A
15. Fixation of leaking points in the water vapor system
16. Adding insulator to the water vapor system
17. Application of water vapor system to heat bunker oil, instead of the use of electrical energy
18. Reuse of condensation

All are emphasized for foods, textiles, and woods categories of factory energy analysis. However, only the first twelve schematics are emphasized for metal and chemical categories of factory energy analysis because processes of these factories are not involved heating energy.

4. Results and Discussions

This section is devoted to discuss results of the energy audits made on those 18 industrial factories. It includes averaged amount of energy consumption by each factory classified for each category. Further, averaged energy savings for each category of factories is discussed as well as the respective investments and potential of energy saving. Furthermore, the analysis is extended to cover scopes of breakeven and finance internal rate of return (FIRR) analysis.

4.1 Amount of Energy Consumption

Results of the surveyed data have been obtained for each factory. For a more meaningful analysis, the results are grouped and then averaged for each category of factories. Figure 1 shows averaged amounts of energy consumption (kWh/y). These amounts can be translated into equivalents of fuel energy uses.

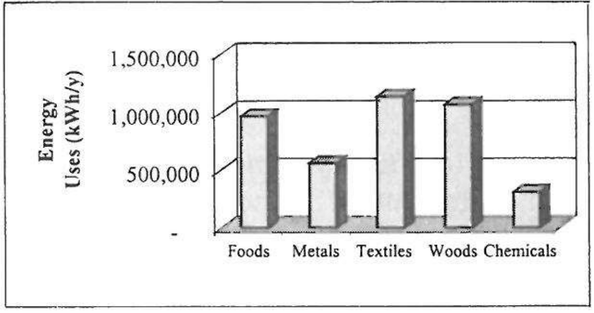

Figure 1 Averaged amounts of energy consumption (kWh/y) for each category of a factory

From the analytical data, it is found that category which has the highest energy consumption is the textiles category. In average, each textile factory uses energy, in electrical term, 1.1 millions kWh/y (or in fuel term 0.11 million LOE/y). Then, woods and foods categories follow, consuming energy almost the same level, at a rate one million kWh/y each. The chemicals category is found to have the lowest energy consumption, 0.3 million kWh/y for each chemicals factory. In addition, the average amount of energy uses of all surveyed factories is found to be 0.8 million-kWh/y.

It should be noted that for this study productivity of factories is not focused and compared due to different natures of activities of individual factories.

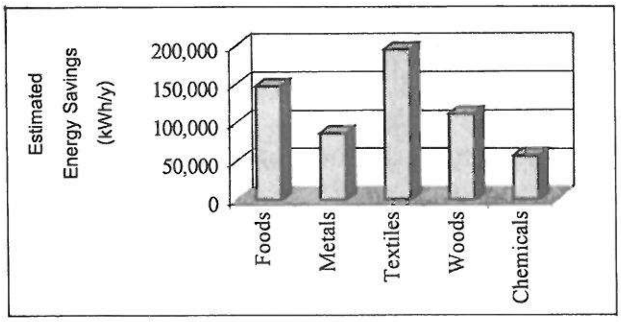

Figure 2 Averaged estimated energy savings for each category of a factory

4.2 Energy Savings for Each Category of Factories

After having done an analysis of the surveyed information, various appropriate approaches for energy savings can be made from all possible alternatives as discussed in section 4. From all categories, it is discovered that the textiles category has the highest potential for energy savings, in electrical term, almost 0.2 million kWh/y (or in fuel term equivalent to twenty thousands LOE/y) for each factory. Additional, a very high possibility of energy savings is found in the foods category, 0.14 million kWh/y. It is also found that the lowest potential of energy savings is the chemicals c·tegory. Details of energy savings for each category are shown in Figure 2.

4.3 Potential of Energy Saving and Investments

An analysis of energy consumption and savings is performed through the use of typical computation by combining energy schematics as explained in section 4. However, many energy saving schematics require various levels amount of investments while some do not need any investment. From the analysis, the categories that need the highest amount of investment are discovered to be foods, and textiles categories. Factories of these categories are estimated to have an investment of about 0.8 million baht each.

Categories of woods and metals are in the middle range scale of investments, about 0.6 million baht each. The chemicals category requires the lowest of investment, less than 0.5 million baht. Such investments, concluded in Figure 3, would bring them on the track of highest energy savings.

Since an investment for each factory is rather a high amount, breakeven analysis is thus applied in order to know a return period of an investment. Figure 4 exhibits an averaged result of the breakeven analysis for respective investment for energy savings. From the overall result comparison, it is found that the lowest period of breakeven is about 2.3 years for the textiles category. The averaged breakeven of all result is 3.12 years.

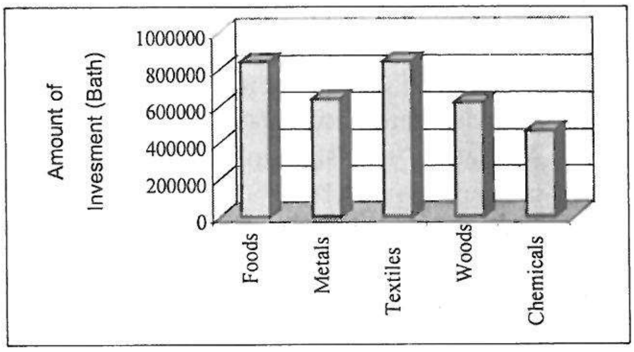

Figure 3 Investment to improve energy efficiency (averaged)

In addition, we have also applied finance internal rate of return (FIRR) analysis to the data. Table 2 displays the outcome of FIRR analysis in percentages. From this study, it is found that textiles, metals, woods, foods, and chemicals categories have percentages of FIRR to be 41.2, 31.5, 30.2, 17.7, and 15.1, respectively. All these numbers are greater than 9%, which is a standard value of FIRR. The average of FIRR of all factories is 27.13%.

Table 2 Averaged breakeven and FIRR

Category of factories	Breakeven (years)	FIRR (%)
Foods	3.53	17.71
Metals	2.88	31.47
Textiles	2.38	41.17
Woods	3.04	30.21
Chemical	3.78	15.09
Average	3.12	27.13

5. Concluding Remarks

From the survey and analysis of energy consumption of eighteen industrial factories within the central region of Thailand, we have found trend of energy consumption (standardization) of each category of factories as discussed in subsection 5.1. Schematics of energy savings involve investments and non-investment portions. The category of textiles factory reveals the highest in both energy consumption and possibility of energy savings. Thus, the corresponding investment is also the highest amount but it yields fastest breakeven which is the highest percentage FIRR. For any factory, in average the breakeven of the investment is less than 3 years. From the energy survey and analysis, the textiles category is thus found to be the highest potential to increase energy efficiency, and thus worth investing.

This study prompts the respective owners and managers of the industrial plants to realize energy related matters concerning production cost reduction as from energy savings. After being learned energy consumption reduction suggestions, most factories first apply measures that do not need investments. Such measures are peak demand reduction, tab electric transformer, motor's belt tension adjustment. However, investments are needed for such measures as installation of a speed control gauge for an air compressor machine, power factors, uses of electronic ballasts, usage of high EER air conditioners, and apply electronic thermostats.

This study is rather an initial process for energy savings within the factory. Still many can be done to increase and improve energy efficiency even further thus slash utility costs. This also has indirect benefits such as global warming reduction, resulted in environmental sustainable.

6. Acknowledgements

We would like to express our sincere thanks to all our staff members for performing and collecting surveyed information. We also would like to extend our thanks to Dr. Sunisa Samittakorn for her kindly helps and invaluable discussions.

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