

Value Engineering and Its Effect in Reduction of Industrial Organization Energy Expenses

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Abstract—The review performed on the condition of energy consumption & rate in Iran, shows that unfortunately the subject of optimization and conservation of energy in active industries of country lacks a practical & effective method and in most factories, the energy consumption and rate is more than in similar industries of industrial countries. The increasing demand of electrical energy and the overheads which it imposes on the organization, forces companies to search for suitable approaches to optimize energy consumption and demand management. Application of value engineering techniques is among these approaches. Value engineering is considered a powerful tool for improving profitability. These tools are used for reduction of expenses, increasing profits, quality improvement, increasing market share, performing works in shorter durations, more efficient utilization of sources & etc.

In this article, we shall review the subject of value engineering and its capabilities for creating effective transformations in industrial organizations, in order to reduce energy costs & the results have been investigated and described during a case study in Mazandaran wood and paper industries, the biggest consumer of energy in north of Iran, for the purpose of presenting the effects of performed tasks in optimization of energy consumption by utilizing value engineering techniques in one case study.

Keywords—Value Engineering (VE), Expense, Energy, Industrial

I. INTRODUCTION

THE development trend accelerated considerably during the last decade, such that all of the industrial countries in the world were trying to complete with each other to be able to supply their populations' needs & also to be a part of international markets competition. The existence of energy for various activities is among mans' necessities & one of the most important ones is electrical energy whose trend of demand is increasing considerably in different countries including Iran [1]. Importance of efficiency in any organization is the result of efficient & effective consumption of resources, reduction of wastes, reduction of final expenses, quality improvement & ... which will cause any organization to grow & progress [2]. In this regard, optimization of energy consumption is the most important transformation that occurs in the economical structure of industrial countries.

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It will present achievements such as economical growth & increase of national gross production rate together with reduction of expenses [3]. Electrical energy is one of the valuable transporters of energy & its cleanliness and easy transportation is one of this energy's advantages and one of the strategic goals of any organization is to consume energy in a suitable and optimized manner [4]. Value engineering is a homogeneous method for reaching the highest value per each monetary unit which is financed & since it is necessary to specify scientific methods for optimization & saving energy considering the trend of our society's consumption pattern consequently value engineering must be the top schedule of production & operational activities.

The goal of present article is to review the optimization process of energy consumption in light of value engineering in Mazandaran Wood & Paper Industries & after reviewing the related literatures with respect to a case study performed in the a/m company in order to introduce the effects of the actions performed for optimizing energy consumption from different aspects in one practical case & observe the effect of "Value Engineering" in the organization. At the end of article, the aim points will be summed-up, concluded, discussed & compared and the managerial applications with the related suggestions will be present for future research.

II. PRESENTING THE PROBLEM

As it was stated, the necessities of a successful organization, is considering the issue of energy consumption, because energy cost is one of the important factors in the final price of products & also the country's future prospects & joining Iran to International Trade organization, necessitate the omission of energy subsidies. On one hand, by pursuing the present trend of energy consumption, all the oil of the country will be consumed locally & exportations will become zero. The pollution of fossil energy & destruction of environment must not be overlooked [1]. Two main solutions have been presented concerning increasing power consumption, the first one is to increase the capacity of power production more than before in the country & another solution is to correct the pattern of power consumption, both for the benefit of consumers and more reasonable distribution of Iran's resources [4]. Here, we shall deal with the second solution & to achieve this goal, we need to revive the present conditions precisely & realize the related shortages and in order to present an appropriate approach, we must change the conditions in a suitable manner & by changing energy structure & consumption patterns, we can provide the opportunity for our organization to develop in fact, by using

value engineering we can increase productivity & decrease organizations expenses. Then, we shall continue the discussion by describing the action taken in this regard during the recent years & the results of the related activities shall be analyzed. These reviews will show the effects and rate of optimization in the organization's energy consumption.

III. VALUE ENGINEERING

Value engineering is one of the necessary tools for showing the value of products in its application & it was used by Miles (1) for the first time. according to miles , value engineering, creative, efficient and organized with the goal of identifying the expenses are not necessary, i.e. the expenses which are not related to quality, operations, useful life, physical beauty & the employers' requested specifications. According to the definitions presented, value engineering is a technical method for specifying activities of producing goods, determining the values of these activities & finally, is a method for specifying the activities with the lowest costs [5].

Despite the fact that the best time for using value engineering is during the initial stages & the initial design phase, but one of the periods during which we can use the capabilities of value engineering, is the maintenance & operation phase. Value engineering in this phase is proposed as an opportunity for changes which were not possible in previous stages (it maybe due to shortage of time & or other limitations). the results of studying value engineering in this phase includes savings in expenses which expending its life cycle by using new materials, processes and / or design, reducing repair costs, energy savings & other operational costs. Performing value engineering is for finding the answer to this question what other solutions will provide the desired efficiencies, processes & products and/or their operations with less expenditure? So, as a project becomes older, the potential of expense reduction will decline. Using value engineering, include the following 3 main phases:

- *The pre-study preparation phase:* in this phase, the actions taken include identification & gathering the required information for the under-study project, selection of the related team & study programming.
- *The VE study workshop phase:* in this stage, the operations design phase will continue .operations design will direct reviewing & studying the parts with high costs & low values. This stage includes six main phases including: information, function analysis, creativity, evaluation, development & presentation.
- *The Post-study phase:* which is also called execution phase includes execution of suggestions confirmed as value engineering & will be considered in the time – scheduling of final design –in this phase, theories can be real.

Various stages of value engineering are presented in the below figure.

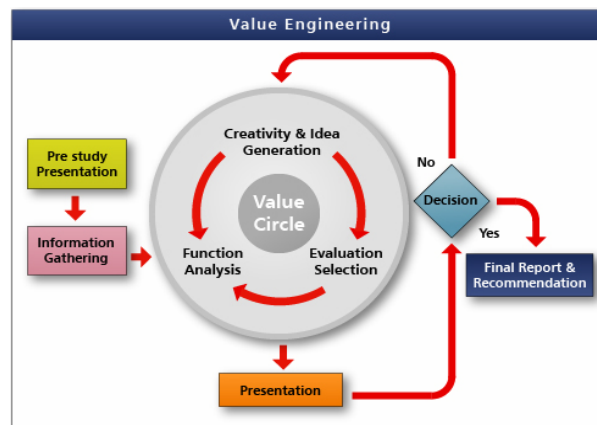


Fig. 1 The stages of value engineering

IV. OPTIMIZATION OF ENERGY CONSUMPTION (PRE-STUDY)

In this phase, studies were done concerning optimization process of energy in industries, other successful methods used in other organizations were evaluated & the specialist team (working team) was formed in this regard. The results of the reviews performed in this regard, includes some points & subjects which can be used for reducing energy consumption. Energy consumption optimization does not depend on the price of consumed energy & its aim is to impose the transformations in organizations by using innovative & internalized methods [6]. The subject of optimizing the consumption & reduction of energy rate, which is one the top level main managers concerns such that they are constantly looking for operation approaches for it, is effected by numerous factors of which the most important ones include the following:

A. Supplying the Capacity of Units

Mechanical equipment & machineries usually function by electrical stimulants, such that to move the motors & its loads (gearbox, fan, pumps & ...) electrical energy is used. on one hand, motors loads are mechanical & they are physical on the other hand physical load can be transported or shifted by the mechanical part & can be gas, water, liquid, air & ... based on the case. When motor is connected to gearbox, about 40% - 60% of the motor's nominal power is consumed for the gearbox & on the other hand when gearbox is exposed to physical load, a small amount of load is added to motors, which forms the final load of motors [7]. Therefore, when a motor perform useful work to move the physical loads of water, gas & ... when it doesn't move any loads, we have energy consumption, but we haven't done any useful work & on the other hand the more the physical load of electro motors, we do not need to consume energy proportionally, but it is precisely vise versa. So, by getting close to nominal capacity, we use less energy in proportion to getting away from nominal capacity. Consequently, high loads use less energy and since in KWH/T ratio (2), the amount of consumed KWH in proportion to the production Ton, shows a reduction, the resulting KWH/T becomes less & this means

using less energy in lieu of specified production. By extending this analysis for all the machines of a unit, we notice that by working with the nominal capacity of a unit, less energy is consumed & in fact we can use the energy in an efficient & optimized manner & consequently we can produce more while consuming less energy. As a result, the KWH/T of the unit will be reduced & ultimately the energy is saved & used in an optimized manner [8].

B. Reduction of Stoppages

The second factor for reducing KWH/T in industries, is reducing stoppages, these stoppages include programmed & un-programmed stoppages. since any type of definite & indefinite stoppages result in production stoppage & on the other hand such stoppages, especially the indefinite forms usually last from a few minutes to several hours during this period all the machineries & electrical equipment are not stopped & only the main stimulants go out of circuit, therefore a high percentage of electrical equipment which have not been stopped consume energy without any production. Concerning definite stoppages, considering the fact that equipment & main machines of a unit stop working almost completely, a considerable number of machines can not be stopped due to the necessity of running the process (such as COM, Mill Water, Air & ...). But un-programmed stoppages have more problems & consequences than short term & programmed stoppages and the increase of KWH/T is a direct & cheap factor, because indirect damages (3) of such stoppages are much more than their indirect ones (4). Early depreciations, possible breakdowns, defects occurring in the elements of equipments in different forms & not preparing spare parts, equipment & tools required for removing defects & ... ultimately increase the stoppages & consumption of energy, whereas in scheduled stoppages, effort is made to stop the unnecessary equipments to reduce energy consumption. Consequently, reduction of stoppages, especially the un-scheduled ones can contribute to conserving energy which ultimately reduces KWH/T.

C. Performance of PM (5)

The third important factor in the discussion of energy optimization is the correct & reasonable a repair & maintenance operations. By performing standard PM in a desirable & precise manner, we can prevent definite & indefinite stoppages. by taking a deep look at the quality of repair & maintenance in different units of the industries, one can observe that a high percentage of stoppages have been unpredicted & un-programmed and if we analyze the stoppages with a little precision, we notice that on-time & suitable repairs could have prevented a high percentage of such stoppages. So, reduction of stoppages means ideal production in a desirable fashion. So, for correct execution of PM, using the documents & repair & maintenance instructions provides us the opportunity to perform maintenance operations in a correct & reasonable manner and during repairs we can use correct methods based on the related standards 7 manufacturer's opinion to repair & correct equipments.

D. Analyzing the Stoppages

Studying the definite & indefinite stoppages & their analysis can be useful in preventing their repetitions & recognizing them correctly in due course. when the stoppages of a complex is reviewed precisely, it is observed that a high percentage of them are indefinite & almost repeated, such that by previous, complete & precise knowledge of them we could have prevented their occurrence in a machine or a system & even in some instances lack of such knowledge causes the stoppage of the related unit which ultimately wastes energy creates the problems resulting from such wastes. Obviously, in such cases, energy consumption increases & consequently the KWH/T rate of the related unit will increase, too.

It is worth mentioning that in some cases, strict laws & regulations of some organizations prevents industries to perform some of these actions. Meanwhile, there are other factors with less effects, but with they have own importance & effectiveness. by more precise review one notices that these factors have important roles in optimization & consumption matters such as physical cleaning & servicing of processing, mechanical & electrical different units, because not cleaning them correctly in due course, will reduce their efficiency up to about 40% [8].

V. THE CONDITION OF ENERGY CONSUMPTION IN MWPI (STUDY)

During the study stage & its different phases, the condition of energy consumption in the above mentioned organization was analyzed. This complex is considered the biggest consumer energy in northern Iran with 35 MW (6) demand (7) electrical energy & 17000 M demand natural gas, and considering high expenses of energy and the fact that these expenses are among the first rank expenses in the company, the necessity of optimizing & consuming energy in this complex doubles. among non-technical factors which can be mentioned in this regard and increases the possibility of success in optimization of energy, is the top manager's sensibility & awareness concerning the necessity of optimizing & conservation of energy, such that after complete commissioning stages of the units during the first years of production, they formed an energy unit & an energy committee in corporation with the organization who are active in conservation & optimization of energy in order to use their experiences in this respect. to review the initial conditions of energy, first we must specify the methods of energy consumption & production and then by precise & reasonable study, we can prepare specified schedules regarding optimization & conservation of energy, such that by analyzing effective factors for reducing KWH/T & by presenting suitable solutions for reducing desirable quality productions we may be able to produce high standard products [7].

On one hand the production & process conditions of some industries such as the a/m complex is such that it is not possible to shut down some units and/or transfer their productions or consumptions to midnight shifts such as many other industries & mills like cement, textile and chalk and ... (8), because the production process system of these industries is a continuous process (9) & so it not possible to change the production periods in operation & energy units & on the other

hand the process & production conditions of some industries is in the form of batch (10) and therefore by systematic & suitable programming in the network, it is possible to reduce the consumption rate even up to 70% which ultimately results in conserving electrical energy up to 10% just by observing this factor and /or in shaving peak (11), There are some machines & equipment which we can remove their start & stop (12), non-simultaneous start of the related units & their peak rates of consumptions, and ultimately by requesting nominal consumed demand [7]. We can have reduced consumed demand in the related network. Consequently one can see that this amount is very small compared to demand reduction of 70% in some other industries. It is worth mentioning that it is not possible to reduce energy expenses a considerable amount in short terms by comprehensive programs, but this important goal is achievable only in long terms & it is possible to program for reduction of energy consumption through low cost & or high cost programs.

At this complex, about 3000 different types of electro motors have been used in pumps, blenders, refiners, gearboxes, conveyors & ... these equipments were selected by a consortium which consisted of some authorized international companies. Power of this equipments, were also specified and then they were utilized. at this complex, 43 HV (13) motors with 6 KV voltage the total power: 36 MW, 32 units of different DC (14) motors with 6 MW power, 80 units of VFD (15) motors with 3 MW power & about 2800 units of normal induction motor with 41 MW power have been installed. considering that the amount of PF (16) in the complex is 95% presently after 4 years of operation, with installation of 10.4 MVAR capacitor during installation period & 9 VAR, more than 10 billion rials, was paid only for the damages resulting from consuming radioactive energy during 4 years which had many consequences considering waste of energy & ...and also had a negative effect on optimum use energy consumption.

VI. MEASURES TAKEN (POST-STUDY)

In developing countries, compulsory factors such as rapid growth of population, development, of cities, increase of welfare level & industrial development have expanded the scopes of energy consumption. In such conditions we must search for solutions concerning reasonable consumption of energy & conservation of the same. In this regard we can use the industrial consumer's help to program the shaving peak, because industrial consumers are concentrated, can be controlled and there are a few of them. By imposing load management, we can reduce expenses in the consumers & producers sector [9]. After reviewing the present conditions, identifying the problems, obstacles, specifying the required strategy & the prioritized approaches, it is the implementation turn & accordingly the conditions must be provided for performance of approaches for achievement of the goals and macro-level missions of the company [10]. Considering the present problems, the organization has selected & performed some approaches during the post-study phase in order to solve the problems & improve the previous consumption process. The main activities of this phase are briefly described as below.

- 1- Reviewing the energy consumption & demand and request for reduction of nominal demand from 45MW to 40MW & then reduction to 35MW.
- 2- Complete stoppage of cutting unit & preparing wood chips with 1MW consumption.
- 3- Stoppage of some machines & equipments of complex units in the network messenger, totally for 1MW considering the measures taken.
- 4- Reviewing the PF condition together with the harmonics of internal network of different units & the requirement for about 9 MVAR of 6 KV and 0.4 capacitors in addition to the available ones which were installed in 2001.
- 5- Programming to prevent undue stoppages of the units' machines & equipment.
- 6- Analyzing the possibility of parallelizing two main transformers in the complex with the power of 2*90 MVA.
- 7- Reviewing the accessibility of using natural light in all the units of complex & testing it in one of the above mentioned units.
- 8- Selection of energy criteria in different units.
- 9- Increasing the sensitivity & awareness of managers, experts & other employees of the complex concerning optimization of energy consumption.
- 10- Close contacts with the related organizations such as SABA organization, institution of international studies & management office of regional power consumption.
- 11- Calculating & reviewing the monthly, weekly & daily ratios of KWH/T consumed by different units.
- 12- Calculating & reviewing amounts of R/T (17), R/KWH (18), PF, active (19) and reactive (20) energy of the complex & comparing them with previous years & global standards.
- 13- Reviewing the possibility of automating (21) the available 20 KV capacitors which are in the circuit in the form of MAN (22).
- 14- Using low-consumption light bulbs & high efficiency.
- 15- Installing keys & controls for lighting, heating & cooling system & non-industrial consumption & ...
- 16- Convening energy committees for the company comprising the managing director, the deputies & the energy department manager.
- 17- Temporarily reducing or removing from the circuits a percentage of lighting systems which are unnecessary.
- 18- Performing the basic repairs in the complex & the installations related to its energy for the warm & cold months of the year.
- 19- Reducing the height of the light bulbs in industrial units & creating suitable conditions for more desirable lighting systems for the personnel of different units.
- 20- Membership in the global committee of energy.
- 21- Imposing local management (23) & shaving peak.
- 22- Feasibility study of installation & commissioning of 25 MW turbo-generator related to the CHP (24) system.
- 23- Experimental testing of using solar energy.

VII. RESULTS AND FINDINGS

Considering the precise reviews performed in different production units & energy consumption, it is observed that KWH/T or the rate of designed consumed energy of the complex is about 1300 & the global standard is about 1000. this matter has not been of considerable concern with regard to the problems accruing during & after the commissioning, but a few month after commissioning, i.e. in the year 1999 during which production conditions improved a little and considering complex's nominal capacity which is 175000 tons/year the production rate reached 60000 tons in this year & the rate of KWH/T in the year 1999 was about 1600. In the year 2009, with a little improvement in the condition of production, repairs & maintenance & other effective factors, the amount of KWH/T reached 1530. In 2001, by actions compiled through the energy department 7 imposing them by the related units, the improvement process become more practical, such that in 2008 it reached 1230 which is an acceptable amount. During recent years all the consumptions, productions & conditions of different units were analyzed & the problems & challenges were identified & the basic approaches were considered. consequently, in 2008 about 50% less energy was consumed compared to 1998 & approximately 50% less energy was used compared to the design amount for the complex, but compared to the global standard we have consumed about 20% more energy.

As it was mentioned in introduction, we are trying to show that in line with increasing production capacity & the need for more energy consumption, the activities of energy management section was adjusted & performed based on value engineering such that the organization has provided the conditions for optimizing energy consumption by imposing complementary strategies in an increasing trend in line with improving energy utilization. The result of the studies based on the available documents are shown in the below figures. In the first figure, the ascending trend of production is shown during the last decade during 1999 to 2009 which in proportion to that, the amount required for more energy can be extracted.

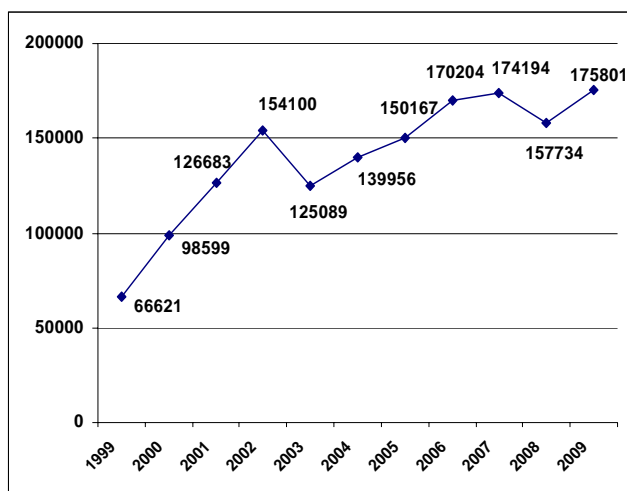


Fig. 2 The production trend in Mazandaran wood & paper industries

In the second figures, the descending trend of stoppages for production lines, resulting from the problems of energy supply & power failures during the same, during the same period is shown which has a noticeable descending slope.

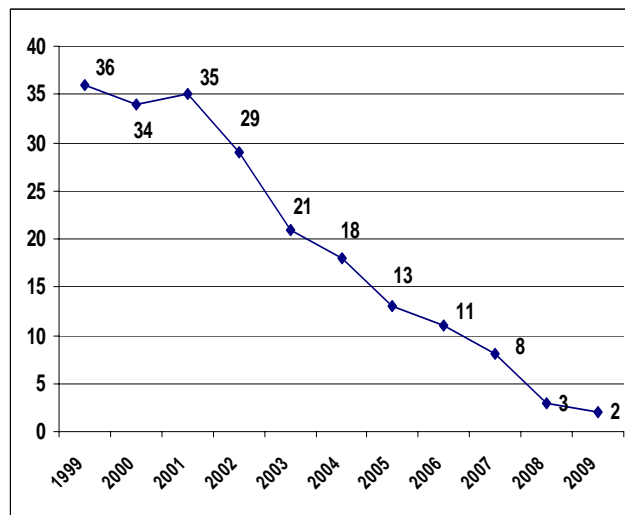


Fig. 3 the number of stoppages trend for production line due to power failure

From financial aspect, energy management's efforts reduced the direct & indirect damages during the above mentioned years and in fact reduced the expenses. In the next figure, the amounts of direct & indirect damages & their total value are shown. The above mentioned amounts follow a meaningful descending trend.

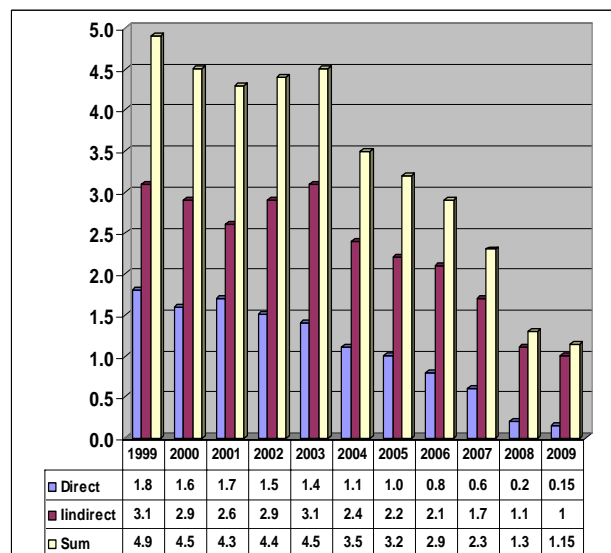


Fig. 4 Damages trend resulting from power failure in billion Rials

The intensity of world's energy standard, the intensity of designed energy for the mill & the trend which these quantities have followed during the considered years, is a subject which has been shown and compared with each other.

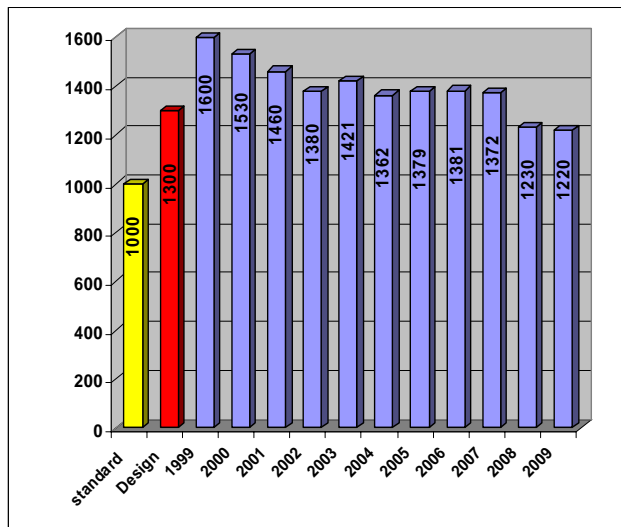


Fig. 5 The trend of energy rate changes & comparing it whit global standards and the mill's design values

In another figure, the effect of value engineering on organization's profit is shown clearly. Energy costs always form a considerable part of goods final prices which in this figure, the descending trend of the energy expense to the total organization's expense ratio during the related years has been indicated.

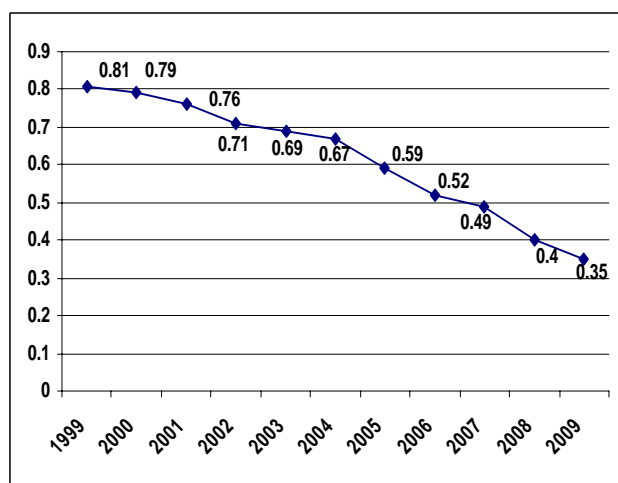


Fig. 6 The trend of changes in ration of energy expenses to the organizations total expenses in percentage

VIII. DISCUSSION AND CONCLUSION

As it was mentioned, by studying designs comprehensively, we can achieve the economic goals of a project by energy auditing (25), we can perform effective logical and scientific approaches for reducing the intensity of energy and achieve the specified goals regarding energy conservation & reduction of the goods of final price. By reducing energy intensity, the energy costs will be reduced for the benefit of the country environmentally.

Despite the fact that in some cases unpredicted matter happen, such as supplying the requirements of production line and/or strict official regulations and/or the problem of international sanctions, one notices that by performing low cost & no cost actions in the a/m company, 20 & 60 billion rials have been saved in electrical energy, considering calculations of the year 2008 in view of economical & national aspect. we can calculate that considering the nominal capacity & average price of electrical energy , how much we can save considering the mentioned factors & since the average monthly price of electrical energy is 40 billion rials in the present year , 50% saving in it , means a saving of more than 20 billion rials. In other words, an amount of 60 billion rials must have been paid annually, whereas now only 40 billion rials is paid instead.

Documents show that despite although the organization has increased the production capacity & energy requirements have increased in general terms , but production line stoppages resulting from lack of energy & the related problems, which can be mentioned as one of the main concerns of the organization, have had an effective role in increasing the company's profitability. This trend has expanded to the extent that the company's consumption electrical energy has become less than the design value & is getting close to international standards. in view of value engineering, energy department's activities during the past 10 years have been performed in such a way that energy's share of expense in the goods final price has reduced to less than half & this result is what we expect of value engineering capabilities in reducing the organization's costs during the initial stage & after performing the plan.

Finally, we shall mention the approaches which could be useful in the near future for optimization & more desirable utilization of the equipment for the purpose of reducing the rates of energy consumption & expenses.

- Reviewing the capacity & power of electro motors based on their loads in the future.
- Selection of electro motors with high PF & efficiency.
- Using high speed of production machines.
- Correct & reasonable repair & maintenance operations based on the manufacturer's instructions.

IX. FOR FUTURE RESEARCHES

Finally, considering the documents presented in the article, we can propose some suggestions for future investigations related to the subject of present article:

- Presenting suitable approaches for increasing efficiency, with optimization of non-electrical energy consumption.
- Reviewing the failure for reducing consumption of unnecessary energy in industry.
- Presenting suitable approaches for improvement of energy's management process.

FOOTNOTES

- 1- Lawrence D. Miles, one of the engineers of American General Electric (GE) during 1960 & creative of value analysis.
- 2- The consumed electrical energy per unit of product [3].
- 3- Indirectly damages that impose after power failure, such as equipment defects (impairment), burning of electronic cards, start / stop problem in production lines.
- 4- Damages which are imposed on the organization directly after power failures and affects non-profitability of production process , such as stoppage of production line which makes production impossible & ...
- 5- Preventive and Maintenance (PM)
- 6- The unit for measuring electrical power. Each Watt is equal to the electrical power produced for one Ampere of current which has one Voltage [11].
- 7- The amount of power demanded by the consumers, such that they can use power whenever they intend to [3].
- 8- It is a period with the maximum energy consumption and it usually occurs during the initial hours of night and during warm months of the year, especially in August [3].
- 9-Continuous process system of production is called continuous system [4].
- 10-A processing system which is not continuous is called Batch system [4].
- 11-Combination of actions which result in reduction of consumption peak is called "peak reduction", Actions such as transferring consumption from the initial hours to midnight hours, stopping some high consumption machineries during peak hours & conservation of energy for the peak hours [3].
- 12- Turning on & turning off the electrical systems which are often used for industrial electro motor. In different industries, if we use start/stop function of electro motors less, the more desirable efficiencies for production lines are obtained [12].
- 13- High voltage: Industrial motors which have high powers & are fed through voltages more than 3 KV [13].
- 14- Direct Current is used in motors of which the feeding voltage does not change with time. These motors are used when it is necessary to control the motor's RPM & its speed precisely.
- 15- Variable Frequency Drives, Includes the electrical motors which are used for remote controlling of various processes of industries [13].
- 16-Power factor: Is the power coefficient of electrical systems such that each electrical industrial machine has a PF close to unity , consumes less active energy & receives less non-effective energy from network and in equal conditions , the powerhouse generators are capable of delivering more capacity to network [4].
- 17- Cost per Ton of the produced goods in Rials [3].
- 18- Cost per KW/h of electrical energy in Rials [3].
- 19- The effective consumed energy of electrical equipment is the active energy of which the measurement unit is in KWh [14].
- 20- Reactive, is the non-effective energy consumed by electrical equipment in KVAR [14].
- 21- Auto means automating the electrical equipment [15].
- 22- Is the electrical system which is located in the circuit manually & non-automatically [11].

- 23- Load management, is the management of electrical energy consumption at macro-level for industries and nations [16].
- 24- Combined heat & power, is the system for combined & simultaneous utilization of heat and force [15].
- 25- Is the combination of actions taken for identifying the method of usage, amounts & conditions of energy consumption in one process or activity during which the opportunities & facilities for conservation of energy are specified and evaluated [3].

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