



## The Factors Effect on Electrical Energy Conservation for Designed Building and Factory

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**Abstract**— The study aims to present four factors influencing on electrical energy conservation for building and factory. The factors include human resources, budget for energy conservation, material and technology, and management. These factors are called 4Ms management concept. The 4Ms concept consists of Man, Money, Material, and Management. It is the principle of management used to get the target of both working and business. Therefore, the 4 factors influence on success work, business and energy conservation. Energy conservation needs to concern about these effects in order to find productively energy conservation solution. Consequently, effects of four factors on energy conservation are discussed in this article by reviewing several literatures in relative content area which study effect of each factor. This brings conclusion of energy conservation solution into practice. Finally, the ways to conserve energy are presented.

**Keywords**— Energy Conservation, electrical energy, 4Ms management, factor of energy conservation.

### 1. INTRODUCTION

Nowadays, the electrical energy is used more and more for responding human needs such as lighting system, air-conditioner, machine in industry, not only that but also electric car or train and so on. Although currently human tries to produce electrical energy from green resources; solar, wind, etc., the conventional form of electricity still is main source. The conventional electrical energy is mostly produced by fossil which is waste energy. Therefore the best choice to conserve energy is using conventional electrical energy effectively and developing the renewable energy continuously [1]. The world demand of energy consumption has been increased continuously. Especially, Asia country group, the consumption is higher than another, because of industry expanding rapidly [2], [3]. The energy conservation needs to do immediately because not far from now the world and Asia will face with the energy crisis seriously. According to Global Statistical yearbook 2016, it showed amount of world energy consumption was increased in the rating of 2.2% [4]. Moreover the electricity demand was also higher up in the rating of 3.0% [5]. The most of countries in the world have been awareness in energy conservation also Thailand. Thailand declared Energy Conservation Act 1992 which the designed building and factory have needed to do energy conservation [6]. The ways to conserve energy were presented in [1]-[3], [7]-[16]. In [2], [3] introduced the ways to conserve energy, for example, setting the team to find the integrated ways,

using technology and using low energy device. Some research suggested that person responsible for energy was important factor [7]-[10], [16]. The factors influenced on energy conservation concluding budget, qualification of person, attitude of people in organization [7]. The companies of energy service for conservation were mentioned that they were main role to get the goal [11]. Improving attitude of person and developing energy saving technology are the point of energy conservation presented in [12]. Intelligent building was high efficiency of conservation as presented in [13]. The Building Energy Management System (BMS) was introduced for energy saving in air conditioner and lighting system [14]. The policy of promotion was presented to get the goal for example price, salary rising etc. [2], [3]. The solutions were discussed in several ways.

In order to get the goal of energy conservation, the factors are discussed in this research. The effect of four factors following by 4Ms concept of management; Man, Money, Material and Management are analyzed and discussed. Finally, the best way for controlling and performing in 4 factors lead to energy conservation.

### 2. ANALYSIS OF ELECTRICAL ENERGY CONSUMPTION

#### *Electricity Consumption*

According to Global Statistical yearbook 2016 in the section of electricity consumption [5], world electricity consumption in 2015 is 20,568 TWH while in 2000 is 13,173 TWH. It illustrates that the electricity consumption is very rapidly increased in 56% in fifteen years comparing. According to information in [5], the graph is plotted in Figure (1). The graph shows electricity consumption since 1990 to 2015 classified by country group. Electricity consumption of all groups is intended highly up. In 1990, America group used the most electricity and the next are Europe and Asia respectively. In 1997, electricity consumption of Asia

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overcomes Europe but it is less than America. Finally, electricity consumption in Asia highly intends continuously until over completely America and Europe in 2007. From the graph, line of Asia is very high slop while America and Europe are almost constant. Especially, in 2015 electricity consumption of Asia is higher double than Europe not only that but also more than America clearly. In 2015, the first three groups are Asia, America and Europe respectively. Therefore, it is time the countries in Asia need to find the solution of electricity conservation.

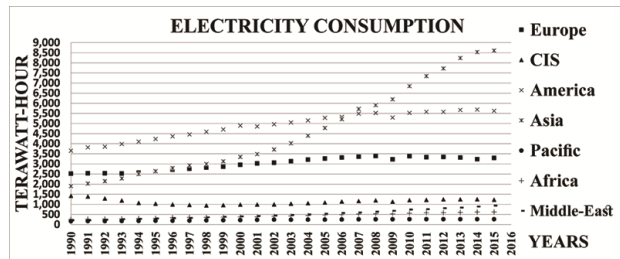


Fig. 1. Electricity Consumption since 1990 to 2015

### 3. ANALYSIS OF EFFECT

#### *The Effect of Human Resources (1st M=Man)*

The human resources in this research mean all people who work together in organization. There are not only that but also personnel responsible for energy who is the important factor.

According to Energy Conservation Act 1992 declared by Ministry of Energy in Thailand [6], the designed building and factory needs the position of personnel responsible for energy. Their functions are to do energy conservation and report to Ministry of Energy. In 2014, research showed that the goal could not get because personnel responsible for energy did not understand following declaration in 1992. Therefore in 2007, the second declaration was written to correct and add information in the topic of the solution to energy management [10]. Therefore, the results showed that Thailand could reduce energy using about 896 million Bath per year or approximately oil equivalent to 37.235 ktoe per year [10]. In 2015, the research in Latvia presented that energy conservation in enterprise did not succeed because of lack of energy professional. Hence research suggested that the Government should appoint professional to perform energy conservation in each state [9]. In [7], proposed the characteristics of personnel responsible for energy influenced on the efficiency of electric energy conservation in designated factories. The characteristics consisted of qualification, certificate of training, time of experience, results of work. In conclusion, the enterprise should appoint the person responsible for energy considering from results of work. The person, who had result of work at high level, was suitable to get the target of electrical energy conservation. In [8], the personnel responsible for energy conservation needed both knowledge of technology, human behaviors, teamwork, motivation, and finally forming organizational culture of energy conservation. Research suggested training in these topics needed.

Administrator is an important factors affecting on electrical energy conservation. Based on research results in [7], the attention and vision of manager influenced on energy conservation. If energy conservation would be successful, manager should attend in high level of performance. Moreover, cooperation of staff in enterprise was one of factors. The results showed if good cooperation of staff was high, the electric energy conservation was high also [7]. The key question was how to make staff cooperation occurred. The possible way was increasing their awareness of energy conservation. In [12] mentioned about two factors, attitude and technology, which influenced on energy conservation for air conditioner in education building. Improving good attitude on economical using of air conditioner and developing technology for energy conservation were considered. Good attitude improving of energy conservation caused on behaviour of energy consumption certainly. Statistic of energy conservation performance showed that changing behaviour of energy consumption was the low cost solution effectively and able to reduce approximately 5-10% [2]. Therefore the Man factor is separated into three sections. Firstly, personnel responsible for energy should be chosen carefully considering experience and worked results. Secondly, administrators should have awareness of energy conservation also. Hence the enterprise should do Job competency. It is difficult chosen person matches the Job competency. But it help to form Training Road Map. Certainly, each different positions have different Job competency. The competency of energy conservation should add to them by function.

#### *The Effect of Budget (2nd M=Money)*

The performance of energy conservation seems to be difficult, if it has not enough supported by one key factor which is money. Research [9], showed the limited budget more effected on efficiency of energy consumption in enterprise. Moreover, the research in [7] which studied the factor influencing on the efficiency of electrical energy conservation in designated factory. It is found that the budget is the one of necessary factors. Therefore the enough budgets will bring success goal of energy conservation. Surely, this means production cost higher up hence the enterprise neglects to perform. The waste of energy consumption occurs and also production cost will be high because of waste energy cost. Considering in the long time, investment of energy conservation will reduce cost and make the benefit higher. If the investment is worth, business owners will realize it important and they will do it. In contrast, employees do not realize it important because they do not get benefit from performance. Furthermore, employees yet work harder than before so success in energy conservation occurs difficultly. Employees should be motivated by engaging training and activities. Another way, the benefit which occurred by performance of energy conservation might give the prize for employees. The solutions will promote employees thinking that it is important because it is positive effect on them.

### ***The Effect of Technology and Device (3rd M=Material)***

In this section, electrical energy conservation technique using technology and device are discussed. This research focuses on only electrical energy in designed building and factory. In [12], technology was the main important factor for energy conservation hence enterprise needed suitable technology. The most of load in designed building consists of lighting system and air conditioner. The best method to conserve energy is using efficiently. In 2013, the research in [14] presented the ways for conservation in building for lighting and air conditioning system using Building Energy Management System (BMS). The research performed at a university. The majority of loads were lighting and air conditioner system. The turn on/off switch was controlled by Intranet Network following schedule. The result showed energy saving was about 14.31%.

Nearly forty per cent of all electrical loads in the building were lighting system [13]. So the solution to reduce energy wastes is use the light effective. In [13] presented an intelligent and efficient light control system. The system would turn ON/OFF switch through two decisions concluding checking people in room by using PIR sensor and checking the level of light intensity enough on using. But drawback of this system is it cannot dim the light. However, this system was able to reduce energy consumption approximately just more than 50%. When talking of lighting system, the new technology mostly interested in present is Light Emission Diode (LED). LED is widely applied in many building and industry because it is high efficiency, even if it is more expensive than conventional light; fluorescent, incandescent, complex fluorescent and so on. The studies showed the advantage of LED overcoming fluorescent and incandescent [17], [18]. The research [17] proposed energy conservation by replacing LED instead of conventional light in cotton cloth factory. The result was investigated that efficiency of LED was more than fluorescent because of no loss on side of lamp. Besides that, LED needed lower power. Despite the cost was higher, the life time was longer than fluorescent. Therefore, considering along of life time, replacing LED is more saving. In [18], the research studied result of electrical conservation for 3,884,720 residents in capital of Thailand by replacing LED. The result showed the most population used 6 watt LED lamp instead of 13 watt complex fluorescent and 40 watt incandescent. The maximum time was approximately 5.93 hour per day in use. The result showed saving was about 66.12% with 1.5 years of breakeven point. Another outstanding point of LED lamp was easy to light dimming [24]. The light dimming system control was limitation of light level following daylight. It was integration between natural light and electrical light. So applying of daylight and LED lamp with dimming system will reduce cost of energy saving [23], [24]. However, designing of building should be controlled only the light passes. The thermal should be the least because air conditioner is more worked from heat increasing.

Another main electrical load in building was air conditioner about 50-65% [20], [22]. Therefore,

reduction of waste energy in air conditioner is a productive way for energy conservation. In [14], proposed turning on/off following schedule. It was sure energy saved. Recently, Thailand promoted running air conditioner at 25 °C. If it was lower than 25 °C, the air conditioner worked hard and brought more electric consumption. Some study about suitable temperature with satisfied people was found. It was observed that suitable temperature was about 24-24.5 °C [12]. Interesting way for energy conservation is improvement of efficiency in air conditioner [20]-[22]. In [20] presented the solution of efficiency increasing evaporative pre-cooling for air cooled chiller in electronic industries of Thailand. The pre-cooling section was installing to reduce temperature before condenser. The result showed energy consumption was decreased about 5.59% with breakeven point of 1.63 years. Another technique was presented heat ventilation for condenser using water [21]. This method could reduce current in compressor of air conditioner. Therefore the electric energy was saved. It would run when condenser was abnormal high temperature. The water would be bumped to reduce heat. The method saved energy about 9.61%. Furthermore, in [22] presented idea of energy conservation in air conditioner. The technique was the control electrical power consumption following the peak demand. The electrical power consumption of building would be compared with set point. If it was equal or more than set point, the system would reduce running air conditioners. This caused the energy consumption was not over peak demand so the cost of energy was lower. Another way for energy conservation is the renewable energy. It is interested more and more especially solar energy. In the past, the knowledge and technology of producing was not enough, hence the cost was high. In [1] suggested that used both of energy; conventional and renewable energy integrated until enough experience to completely use renewable energy. Nowadays, the cost of solar energy is cheaper than the past. Therefore this energy should be used. However, the main trouble still is age of battery which is about two or three years. If the battery is not used, this means solar energy is used only day time. That is enough for air conditioner and lighting system on day time. It is able to save the cost of energy.

### ***The Effect on Management (4th M=Management)***

Other main factor very important influencing on success of energy conservation is management. The performance by every section concerning energy conservation with good management would get the goal. A process of 4 steps for energy conservation in the regional level in Latvia was presented as shown in Figure (2) [9]. In Thailand, Energy Conservation Act 1992 (amended 2007) was declared. It suggested 8 steps for energy conservation in designed building and factory [2], [6], [10]. The process is shown in Figure (3).

The result of performance following 8 steps was presented in [10]. It showed that the energy consumption could able to reduce about 896 million Bath per year or 37.235 ktoe oil equivalence or about 4% [10]. Another, personnel participation for energy management was

mentioned [19]. The study suggested solution for high efficient energy conservation to get the goal of conversation. Enterprises and government needed to participate. The enterprise consisted of administrators and personnel in enterprise. The representative of government concluded agencies from Department of Alternative Energy Department an Efficiency, Provincial energy office, and consultant who assigned by government. The designed factory and building needed continuously plan and made public relations by using suitable media. The enterprise should listen to the opinion of employees about energy conservation. In addition the government should directly give information of energy conversation to administrators and provide team to visit enterprise.

1	Drawing the plan of energy conservation for each region
2	Providing meeting among responsible person for energy and leader of enterprise in region
3	Implementing of informative activities, informative seminars, open discus and booklets
4	Controlling the implementation process of idea

Fig.2. The process of energy management.

1	Appointing the committee group for energy conservation
2	Evaluating basically situation of energy conservation
3	Setting the policies
4	Evaluating competency of energy conservation
5	Setting the goal and plane of energy conservation
6	Organizing, controlling, checking and analyzing the performance
7	Monitoring and evaluating energy management
8	Analyzing and solving mistake

Fig.3. The process of energy management.

4. DISCUSSION

After reviewed several literatures, the model of energy conservation is obtained as shown in Figure (4). The four factors is relation together. Therefore to get the goal of energy conservation, they should be considered. Man factor can conserve energy about 5-10%. Every personnel would be trained for changing behaviour of energy consumption [2]. Management factor can conserve energy about 4% [10]. Material factor can conserve energy the most about 6-65%. Before performing, Money factor is considered. Material factor

needs the most budget. While Man and Management factor are low cost solutions. Therefore Man and Management should perform first. Then Material is performed carefully by considering Money factor. It is very important that personnel responsible for energy should be assigned. The research showed personnel responsible for energy is very important factor [7]. They would help energy conservation successful. Therefore they should be chosen carefully considering worked results.

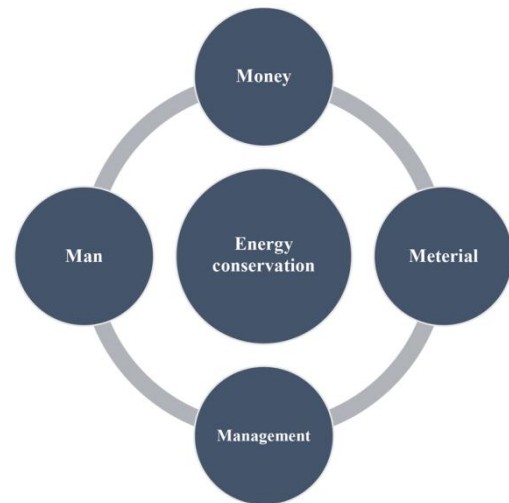


Fig.4. The model of energy conservation.

5. CONCLUSION

The research presents four factors effecting on energy conservation as following.

1. Human Resources effected on energy conservation especially person who directly is responsible for energy hence the enterprise should assign experience person for performance by considering the past worked result. The enterprise should made Job Competency and Training Road Map for developing personnel.
2. Enough budgets will caused on success of energy conservation.
3. Low energy device should be used such as LED lamp, efficient air conditioner. The automatic control system for light system and air condition should be used for energy conservation.
4. The effective management could help to get the goal of conversation. The processes of 8 steps are suggested.
5. Material factor can conserve energy the most about 6-65%. The next were Man and Management factor at 5-10% and 4% respectively.
6. In the term of Money factor, Material factor needs the most budget while Man and Management factor are low cost solutions. Therefore Man and Management should perform first and then Material.

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