International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-2 Issue-2, May 2013

Policies and Strategies for the Improvement in Energy Efficiency in Industries – Indian Experience

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Abstract— Energy has become the basic need of human beings. With technological advancements the supply-demand gap is alarmingly increasing globally. This causes burden on the nation like increase in generation capacity or energy import. Energy policies and regulations are framed by various nations. Majority of energy is consumed by industrial sector. An effort in energy conservation by improving the energy efficiency in industries in the light of these policies and strategies formed for industries to improve the energy efficiency can be effective. In this paper, the energy policies of some nations including India are discussed. Energy saving strategies for industries are proposed. Energy efficiency can be improved by these strategies. A sample case study in an industry and the results show that the operation of the equipment and machineries in accordance with the policies and regulations has resulted in 12% of average saving in energy with less or no investments.

Index Terms— Energy conservation, energy policies, energy strategies, energy saving

I. INTRODUCTION

'Energy' is the basic need of human beings. It is an integral component of a modern economy and is an essential ingredient in nearly all goods and services. All the activities taking place in the nature are the transformation of energy from one form or the other. Energy is needed for all the energy sectors like transport, industries, domestic and commercial. This results in increase in per capita consumption. Presently, the gap in supply and demand is 11.35% at global level and in India it is 8.6% which is consistent[1]. Globally, the gap between the supply and demand is rapidly increasing which may pose serious challenge to the world. This problem can be mitigated by the following broad solutions:

i. By increasing generation capacity: It is achieved only by installing the generating stations. But creation of new power generation capacity is costly, necessitates long gestation period, needs lot of space and involves many techno-economic –social issues.

ii. By avoiding the increase in generation capacity: It is achieved by the methods like reduction in energy losses/leakages, energy conservation at end user (customer) side. This procedure needs less investment, time, effort and is easy to implement at all end users.

iii. Promotion of EE will contribute to energy conservation and can be termed as part of energy conservation promotional policies. Therefore, EC in industries assumes significance in the present energy scenario in India. Since the subject energy has become issue, energy policies and regulations are needed at national level. EC measures supported by the policies, standards, regulations and strategies energy related issues can be addressed successfully. Governments are the critical participants in the development and popularizing the energy technologies to the nation. The objective of policies and regulations is to reduce the supply-demand gap, streamline the efficient use of energy by incentivizing and ensuring reliability. Their significance can be listed as below [2],[3]:

i. Encouraging the energy activities
ii. Energy saving
iii. Revenue generation
iv. Environment balance
v. Reduction in national burden
vi. Avoiding the dependence
vii. Improvement in energy efficiency

A detailed India energy scenario is discussed in [1]. In [2] and [3] the challenges of power, methods for meeting the demand and future trends are discussed. References[4]-[6] discuss the energy status of energy and strategies in various nations. The scope of using renewable energy is presented in [7]. References [8]- [9] discuss the energy saving methods in industries in the back drop of Indian and international energy policies and regulation framework. The organization of this paper is, with first section dealing with introduction and literature survey, in second section the energy conservation in industries and its significance are discussed. In third section, energy policies, regulatory details and strategies of energy conservation in some nations and implementation with reference to present energy policies in Indian industrial sector are discussed. A sample case study is presented in section four followed by the sections of results and conclusions.

Revised Manuscript Received on 30 May 2013.
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II. ENERGY CONSERVATION (EC) IN INDUSTRIES

EC is the procedure to avoid wastage and save the energy in an energy system without affecting productivity and comfort. It would reduce the demand of energy and results in avoiding the capacity increase. Industries consume around 50% of energy in India. Therefore, EC efforts in industries will be advantageous. It involves the following steps[8]:

a. *Attitude of management and employees*
b. *Energy Auditing (EA*): to know how the energy is used by the utilities
c. *Energy planning and management(EM):* optimum use energy or load management (LM)
d. *Energy Efficiency (EE):* to improve the efficiency of individual and overall system. It is achieved by:

ii. Up gradation/ use of new technology/ modernization
iii. Replacement/retrofit/ rectification
iiii. Equipment Maintenance: break down / preventive /predictive
iiv. Efficient operation of equipment or plant

e. *Safety and protection*
f. *Assessment and evaluation*

III. ENERGY POLICIES AND STRATEGIES FOR INDUSTRIES

The need of present day for industrial sector is to be sustainable for the future growth. This is possible if the industries are strong in energy efficiency. Therefore, proper energy policies, regulations and strategies are essential for a nation. The energy policies, standards and initiatives are of some countries and India given below:

A. Global [10]-[12]

i.Singapore

Singapore has passed a new Energy Conservation Bill, 'Energy Conservation Act2012' in April2012 which aims to introduce mandatory energy management practices for energy users in the industrial sector and encourages energy efficiency

ii.Europe

The European Union member states have agreed on renewable energy targets, increasing the share of primary energy by increasing the proportion of electricity generated from renewable sources.

iii.USA

U.S has enacted the Energy Policy Act of 2005 (EPact) in 2007 which serves as the first comprehensive national energy legislation. It has influence on energy efficiency, renewable energy development and energy related matters.

iv. Australia

The policy of the government is aimed at reducing the rate of growth of Australia's dependency on imported oil.

v. Russia

The Energy policy of Russia is contained in an Energy Strategy document, which sets out policy for the period up to 2020. In 2000 the Russian government approved the main provisions of the Russian energy strategy to 2020, and in 2003 the new Russian energy strategy was confirmed by the government..

vi. China

Conservation Law was passed in 1997. State council has given more importance to energy efficiency measures by incentivizing.

B. Global Energy Standards

These standards are framed after meticulously working and testing in real time conditions. Therefore they are reliable. Some of such standards are discussed below:

ISO Series *:* This voluntary standard, developed by a project committee of 45 partnering countries from the International Organization for Standardization (ISO), provides organizations with a framework for continuous energy performance improvements. The framework will encourage adoption of best practices that reduce the energy use of existing equipment and facilities, require the use of energy performance data to target cost-effective upgrades, and emphasize the design and installation of highly efficient energy systems and equipment. They include various series as mentioned below:

ISO 9001: Is an international Standard which sets standards that assure that customers get the quality they expected.

ISO 14001: An Environmental Management System is a set of processes and practices that enable an organization to reduce its environmental impacts and increase its operating efficiency.

ISO 16001: The overall aim of this standard is to help organizations establish systems and processes necessary to improve energy efficiency. This should lead to reductions in cost and in greenhouse gas emissions through the systematic management of energy.

ISO 150001: New standard which the US Department of Energy (DOE) on 20 June 2011 has recognized the publication of ISO 50001, a new global energy efficiency and energy management standard which will help oganizations worldwide save money in their buildings and industrial facilities.

Organizations adopting the standard can expect to achieve measurable energy savings in as little as two years. This projection is based on five U.S. industrial pilot projects conducted between 2008 and 2010 that adopted the American National Standard, ANSI MSE 2000:2008, which was used as an example in developing the ISO 50001 standard. These facilities achieved energy efficiency improvements between 6.5% and 17% over a period of 2-3 years.

US DOE's Industrial Technologies Program and Building Technologies Program are supporting implementation of the ISO 50001 standard for industrial and commercial facilities through the voluntary superior energy performance certification program, a new comprehensive energy management program that provides facilities with a roadmap for achieving continual improvement in energy efficiency.

IEEE Standards **[11]:**

IEEE is renowned international professional organization engaged in research and technical activities. The standards of IEEE are well accepted in many countries and industries. The policy statement of IEEE PES society issued in May/June2007 states that it is concerned with the increase in the production, delivery and use of electrical energy, and its effect on the environment.

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It encourages governments to promote research, development, commercialization, and utilization of energy as parts of comprehensive, national energy strategies. Following are some standards concerned with energy:

i. *IEEE Std.739-1984 :* IEEE recommended practice for energy conservation and cost effective planning in industrial facilities
ii. *IEEE Std 399-1997:* IEEE recommended practice for industrial and commercial power systems analysis
iii. *IEEE Std 902-1998* : IEEE Guide for Maintenance, operation, and safety of industrial and commercial power systems

Energy Efficiency Resource Standard(EERS)

Formulated by US DOE, is simple market based mechanism to encourage more efficient generation, transmission, use of electricity and natural gas. It consists of energy saving targets for utilities and end users with flexibility viewed from market angles. It provides the guidelines for energy conservation.

C. Energy Strategies

Regulatory Measures: There are several regulatory measures that can produce energy savings in the industrial sector. These include:

i. minimum energy performance standards. Some countries like Singapore have introduced regulations requiring office equipment to meet minimum standards of energy efficiency
ii. deregulation of the electricity industry to encourage the development of cogeneration like in China
iii. building codes can be used to ensure that new buildings meet minimum standards for passive solar design in order to reduce energy use implemented in UK and US
iv. changes in the regulatory environment as a result of the control of emissions, such as carbon dioxide and international obligations, such as United Nations protocols in European countries.

D. India [13]-[16]

In view of the energy problem prevalent in India, effective policies and strategies are promulgated. The issues addressed are mentioned below:

i Rural electrification
ii Generation , transmission and distribution
iii Technology development and research and development (R&D)
iv Competition aimed at consumer benefits
v Environmental Issues
vi Training and awareness in energy conservation
vii Industrial energy saving

State Governments have also formed their schemes which support the policies of Central Government . Some important policies and initiatives are enumerated below:

The National Electricity Policy(NEP)

It aims at laying guidelines for accelerated development of the power sector, providing supply of electricity to all areas and protecting interests of consumers and other stakeholders keeping in view availability of energy resources, technology available to exploit these resources, economics of generation using different resources, and energy security issues. The NEP has been evolved by Ministry of Power (MOP) Government of India(GOI) in consultation with and taking into account the views of the State Governments, Central Government bodies like Central Electricity Authority (CEA), Central Electricity Regulatory Commission (CERC) and other stakeholders. National Electricity Plan is part of NEP prepared by CEA in consultation with all the stakeholders including state governments which would, at state level, undertake this exercise. It has framework for short term (5 years) implementation but with long term(15 years) perspective .

Aims and Objectives of NEP:

i. Access to all : electricity available to all by 2020.
ii. Supply of reliable and quality power of specified standards in an efficient manner and at reasonable rates.
iii. Improving energy efficiency in Industries, through certification of energy savings that could be traded.
iv. Accelerating the shift to energy efficient appliances in designated sectors through affordability.
v. Helping finance demand side management programs by capturing future energy savings.
vi. Developing fiscal instruments to promote efficiency.
vii. Per capita availability of electricity to be increased to over 1000 units by 2012.
viii. Minimum lifeline consumption of 1 unit/household/day by the year 2012.
ix. Financial turnaround and commercial viability of electricity sector.
x. Protection of consumers' interests.

Electricity Act, 2003 (EA2003)

The Government has enacted Electricity Act, 2003 which seeks to bring about a qualitative transformation of the electricity sector. The objectives of the Act are 'to consolidate the laws relating to generation, transmission, distribution, trading and use of electricity and generally for taking measures conducive to development of electricity industry, promoting competition therein, protecting interest of consumers and supply of electricity to all areas, rationalization of electricity tariff, ensuring transparent policies regarding subsidies, promotion of efficient and environmentally benign policies, constitution of CEA, regulatory commissions, establishment of appellate tribunal'. Salient features of ECA2003 are , provision of electricity for rural areas, deregulation of electricity, licensing, open access for T & D , regulation in metering and trading

The Energy Conservation Act, 2001 (ECA2001)

It was enacted in 2001 in view of potential of energy conservation and its benefits. The objectives are bridging the gap between demand and supply, reducing environmental emissions through energy saving and to effectively overcome the barrier, The Act provides the much-needed legal framework and institutional arrangement for embarking on an energy efficiency drive. Under the provisions of the ECA2001, Bureau of Energy Efficiency(BEE) has been established in 2002 which would be responsible for implementation of policy programmes and coordination of implementation of energy conservation activities. Main features of ECA20013 are standards and labelling, enlisting of designated consumers for energy activities, certification of energy manager(EM) and energy auditor(EA) and regulation of compliance from consumers.

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Under the act, it is mandatory for the high tension consumers to conduct energy audit by certified energy auditor.

Energy Efficiency(EE) Strategies For Indian Industries

EE strategies are broadly classified as:

i.Short term

ii.Long term

Short term strategies are result of streamlined operation of the plant, efficient use of energy consuming equipment, reduction in the wastage of energy, timely maintenance of equipment, training and continual monitoring of the energy consumption of the industrial process. Long term strategies include retrofitting or introducing new energy efficient technologies with high investments. The returns will be energy saving of long term period. The implementations of the strategies depend on many factors like financial conditions, resources and awareness. Under EE policy, many strategies are enacted in India that enable the end user to derive benefits like subsidy, incentives, rebate or earning or revenue, after successful implementation in industries. Some major schemes are mentioned below:

a. Bachat lamp yojana
b. Standards and labeling scheme
c. Energy Conservation Building Code (ECBC)
d. Demand side management(DSM)
e. Operationalising ECA2001 by strengthening institutional capacity of State Designated Agencies (SDAs)
f. Promotion of EE in industries
g. Contribution to state EC fund (CECF) Scheme

From energy efficiency point of view, Indian industrial sector suffers from many setbacks. Some of them are less awareness, use of obsolete technologies, less inclination in energy saving implementations and low priority for energy saving. But with the help of the strategies discussed and by using the government schemes, energy efficiency can be certainly increased in industries.

IV. SAMPLE CASE STUDY

An industry M/s Shree Automotive Pvt. Ltd in Pune, India, was selected for the case study. Some of the techniques discussed above were applied for EE in the industry.

***Profile of industry*:**

The company was established before 18 years. The products are automobile components of two and four wheelers. All the machineries work on electric power. The turnover is around Rs.50 million. (USD$1=IND Rs.55) per annum. The employee strength is 125 which includes skilled and unskilled personnel like manager, supervisors, machine operators, welders, fitters, lathe machine operators and attendants. The unit is energy intensive and operated generally for 12 hours per day in two shifts. First from 8.00 a.m to 4.00 pm for 8 hours as regular shift and remaining 4 hours during 4.00 pm to 12.00 midnight as per the convenience. Technical details are shown in Table. I as per the monthly energy billing.

Technical:

The power is supplied by Maharashtra State Electricity Distribution Co. Ltd(MSEDCL), a state owned company As per IEEE Std.739 on energy management, all the machineries are provided with unique nomenclature (as M1, M2). The machines are listed as shown in Table.II which indicates the load profile of the company.

Implementations

The study was started from July 2011 and continued till December 2011 for six months. It was stretched into two stages, comprising of three months each named as 'before' and 'after' the implementations to justify the actions taken. The operating conditions of all the machineries during the period were maintained same for the purpose of study.

Following strategies are implemented:

i. Motors

a. Energy Efficient Motors(EEM):

On experimental basis,three motors were retrofitted with EEM as per the Table.III. Energy saving: average of 3.07% for three motors. There are 15 old motors having efficiencies of 70%. If they are retrofitted with EEM 15% of energy (6000units) can be saved per month.

Investment: Rs. 300000.00

Pay back period : 12 months.

Table. I Company profile

Sl. No.	Particulars	Details	Remark
1.	Supply	3 ph. 440V , 50 Hz 4wire	L T consumer (Special)
2.	Sanctioned load	115kW	
3.	Sanctioned MD	125kVA	
4.	Connected load	125kW	
5.	Average energy consumption	40000 units(kWh)	Month
6.	Power factor (average)	0.98	Month
7.	Average MD (recorded)	105kVA	Month

Table .II Load profile of industry (connected load)

Sl. No.	Equipment	Rating	Qty.	Load
1.	CNC machines i. 6mm^2 COB make ii. 10mm ACE make iii.12mm^2 Jobber make iv. 10mm^2 Galaxy make	 2kW 3.5kW 3kW 2.5kW	 2 3 2 4	Dynamic
2.	Lathe machines i. 8ft. ii. 4ft. iii. 6ft.	 2.kW 1kW 1.5kW	 3 5 3	Dynamic
3.	Die Casting machines	1.5kW	3	Dynamic
4.	Furnace	2.5kW	2	Static
5.	Compressors	1.5kW	3	Dynamic
6.	Surface grinder	2kW	3	Dynamic
7.	Drillers	1kW	3	Dynamic
8.	Bending machines	1kW	3	Dynamic
9.	Drilling machines i. Heavy duty ii. Light duty	 1kW 0.25kW	 2 2	Dynamic
10.	Crane	5kW	1	Dynamic
11.	Power Press	5kW	2	Dynamic
12.	Welding machines i. Transformer ii.Generator	 16kVA 5kVA	 1 2	 Static Dynamic
13.	Pumps	2.5kW	2	Dynamic
14.	Lighting	15kW	-	Static
Total		**125kW**	**51**	

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Table. III. Energy saving with EEM

Sl. No.	Rating (kW)	Efficiency (%)		Percentage Loading	Saving (units)		% saving
		η_{old}	η_{EEM}		daily	Monthly	
1	2.5	75	94	0.75	151.59	454.77	3.07%
2	3.0	80	95	0.75	133.22	399.66	
3	5.0	82	95	0.75	187.74	375.48	
Total					**472.55**	**1229.91**	

b. Motor maintenance

One pump of 2.5kW, one bending machine of 1kW and one compressor of 1.5kW were found to be loaded for 40%. They were down sized to 1.5kW, 0.75kW and 1kW respectively. The alignments of all the machines were corrected. Winding connections of six motors were changed from delta to star to improve power factor and reduce iron loss. Maintenance schedule was prepared for the overhauling of motors.

Energy saving :1500 units(3.25%) per month
Investment : Rs. 50000.00
Payback period : 6 months

ii. Demand Side Management(DSM)

As per the priority of the loads following DSM techniques were implemented:

a. Peak Clipping : Switching off the low priority loads at system peak to avoid more tariff.

b. Load shifting: Shifting of the low priority loads at off peak hours.

Energy saving: earning of the incentive as the loads were operated during off peak hours was equivalent to 1000 units (2.5%) per month.

Investment: nil.

iii. Training And Awareness

Periodic training programs were scheduled for managers, supervisor and operators. Various aspects of energy saving at personal level to organization level were discussed with demonstrations. The ECA2001 and EA2003 and other electricity safety rules were discussed in detail during the training sessions. Due to this activity the energy saving achieved was 1500 units.

Energy saving:1200 units(3.00%) per month
Investment: Rs. 25000.00
Pay back period : 4 months

V. RESULTS

After the implementations, of the strategies, total energy saving achieved was 4929,91 units per month which was 12.3% of the total consumption of the company. The results are shown in Table.IV. Financial gain was started by way of energy savings. The energy efficiency of the company was increased by the initiative.

Table. IV. Energy saving

Sl. No.	Strategies	Energy Saving per month	
		Units (kWh)	Percentage
i.	Motor Load	2729.91	6.8 %
ii.	DSM	1000	2.5 %
iii.	Training and awareness	1200	3.0 %
	Total	**4929,91**	**12.3%**

Total investment is Rs. 75000.00. The payback period varies with the strategies. But overall payback period is around 12 months. These results are monitored for three months before and three months after the implementations of the strategies.

VI. CONCLUSIONS

Improvement on energy efficiency in industrial sector is more significant during the present energy scarcity that India is facing. The goal can be achieved by adopting the guidelines of energy policies and following the regulations. By implementing just three strategies, it is observed that 4929.91 units of energy conservation is achieved in an industry. This is 12.3% of the overall energy consumption of the company. The strategies are simple and acceptable for any industry. Such small efforts are certainly needed for industrial areas which results in reduction in supply-demand gap. This calls for the avoiding the increase in capacity addition helping in the reduction in the national burden of energy import.

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