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Step towards sustainable energy: practices and approaches

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Abstract – Nowadays, the study of alternative and sustainable sources is among one of the most important factors of engineering sciences. Sustainable sources like solar, wind, hydro and tidal could became an alternative to these fossil fuels which has been extensively used from past decades. The need of replacing fossil fuels arises in the light of economic crises and also more and more stringent environmental constraints. There is a direct relationship between the energy demand and environment. For a continuous development; every society must ideally take steps to minimize the impact cause on environment by harmful ways of energy development in order to fulfill their own needs. However, the major drawback with it, is that, every energy resource available lead to some kind of environmental impact. In this case, it is reasonable to suggest some resources over others which gives enough efficiency while minimizing environmental impact i.e. to get the same product by utilizing less resources and generating minimum pollution; higher efficiency can be achieved. As adopting sustainable energy resources, as a source of generating electricity for our daily life is a long-term phenomenon that is it takes time, planning and investment too. A forthcoming solution of this is using the energy we are already generating 'Efficiently'. Through sustainable energy management techniques, we can not only use energy efficiently, precisely and economically, but by adopting this techniques in an organization we could evaluate the effect of rapid price fluctuation on its organizations operations in order to sustain in volatile market. This paper discusses all the modern time approaches and practices to harness energy efficiently and effectively backed with real world case study.

Keywords – (SEM) Sustainable energy management, energy efficiency, sustainable energy approaches and renewable sources

I. INTRODUCTION

To survive in today's market, the demand of organizational efficiency in factors like energy, investments and work force is increasing day by day. Nowadays, energy is considered to be a most vital factor for the reduction of operating margin. However, firms need to evaluate the effect of rapid price fluctuation on its operations in order to sustain in volatile market. The key step to control this problem is to smartly reduce the cost relating to energy sector and utilize it somewhere else.

In this highly competitive market, organizations should reduce all the extra cost in their operations, in order to sustain longer. Energy is one of the factors, which consumes a large proportion of organizational budget. However, recently a large decline in energy cost has been noticed; but cost of energy will remain volatile. Therefore, sustainable energy generation alongsustainable energy management practices must be realigned with normal industrial operations in order to extract as much from it as we can. For example, U.S is strongly emphasizing on energy independence and efficiency, for this purpose a bill "American Reinvestment and Recovery Act" has been passed by congress. The main features of this bill are discussed below.

American Reinvestment and Recovery Act (ARRA)

Act is also commonly known as *The Stimulus.* This act was enforced by 111th congress on February 2009 and later signed into law by President Mr Barack Obama on 17th February 2009. The primary objective of ARRA was to create vacancies on immediate basis. The secondary objective was to directly invest in infrastructure, health, education and most importantly renewable energy and its management schemes. The initial allocated budget for ARRA was $787billion, which was later revised to $832billion during 2009 to 2019 [1].

Total budget allocated for investment in energy sector was $27.2 billion, mainly in renewable Vitality. However, this budget was further distributed in following manner to utilize it more efficiently: $6.3 billion to state and local governments; allowing them to invest in energy efficiency projects, $4.5 billion to federal buildings to increase their energy efficiency, $6 as independents renewable power generation loans at easy mark-up; allowing small firms to generate their own electricity and $11 for the modernization and maintenance of U.S electrical power grid.

Beside material cost, energy cost is a major pressure factor for several organizations and manufacturers. A sound and easy to

implement business strategy can yield more production stability by reducing cost. In order to work in profit and with efficiency, modern operations largely depend on the low cost of energy it consumes. Energy conservation and independence are also considered as major strategies for creating a competitive advantage in business. Realizing the fact, that energy management could play a vital role in addressing social, economic and environmental concerns, organization are readily adopting these practices to minimize the risks. Overall, energy efficiency and management practices are among the most important option to increase the profit of organization as well as to reduce their dependencies on highly volatile fossil fuel prices.

A. Economic Factors of SEM

Energy management and saving is really an important at any all levels of human interference, whether it's an organization, a nation, a small scale institute or an individual. This practice reduces the energy cost and increases the overall profitability of organization. For example, Thailand started to take steps for energy conservation and efficiency after the first oil crises in (1973). In this regard, "Energy Conservation Act" was put into action in 1992. Moreover, the announcement of "National Energy Conservation Strategic Plan" (2002-2011) and "Five year Conservation Plan" (2002-2006) took place. The notion-wide joined effort towards energy efficiency plays a vital role in reducing their dependency on costly energy resources i.e. crude oil [2].

Private organizations are widely affected by energy cost; this not only directly affects their profitability but also affects their viability to sustain in global market. The higher the cost of consumed energy will be, the higher will be the cost of product in world market, which can never be a good sign for national trade.

B. Environmental Factors of SEM

SEM is also concerned with the environmental problems of the nation. Environmental concerns mainly have to deal with the emission of carbon foot prints and other Green House Gasses (GHG) in earth's atmosphere. These problems are stated as global warming or climate change. These factors are not only rising the earth's annual average temperature but are also considered as the major reason of ozone depletion. SEM, especially minimizing use of fossil fuel is the major among various countermeasures of this problem.

For the solution of the said issue, there have been numerous worldwide or universal participation activities. One of those is IPCC (Intergovernmental Panel on Climate Change), which began in November 1988. It has three working groups and one task force. One of six directors of the group originates from Thailand. There are also numerous steps have been taken after the formation of United Nations Framework Convention on Climate Change (UNFCC), in which various nations co-operates for the effort of reducing GHG emission.

II. PILLARS OF SUSTAINABLE ENERGY

A. Better Efficiency

Development in energy sector is the key to guarantee reliable, competitive, safe and sustainable life in future. This parameter is most important for every country to progress as through this they could address there several deficiencies like: security, environmental concerns and economic challenges. The efficiency of any system could be measured by the amount of raw material it uses to develop a certain amount of output. So, beside input material cost, developed energy cost is a major pressure factor for several organizations and manufacturers. A sound and easy to implement business strategy can yield more production stability by reducing cost. In order to work in profit and with efficiency, modern operations largely depend on the low cost of energy it consumes. Energy conservation and independence are also considered as major strategies for creating a competitive advantage in business. Realizing the fact, that energy management could play a vital role in addressing social, economic and environmental concerns, organization are readily adopting these practices to minimize the risks. Overall, energy efficiency and management practices are among the most important option to increase the profit of organization as well as to reduce their dependencies on highly volatile fossil fuel prices.

The best way to understand this fact is by going through some examples like: In smarter home, the conventional windows has now been replaced with energy efficient one, these windows prevents heat from escaping in the winter and from entering in summers using several layers of insulation material within it. By installing it you can easily save energy by turning off your heaters in winter and air conditioners in summers. While at the same time doing so will not affect your comfort in any ways. In a similar way, when you replace you old air conditioner with new DC inverter technology or your old big tower PC with latest generation PC and other equipment's with several energy efficient models, this will not only save your money but also minimize the greenhouse gas emission into the atmosphere.

Most of the times people get confuse in between two phenomenon which is energy efficiency and energy conservation. Energy conservation is basically a way to save energy while compromising your comfort as well. For example: turning of the light of room is energy conservation. But replacing, old florescent lamp with modern energy savers in energy efficiency. But however, both of these phenomenon can reduce greenhouse emission.

B. Better Cost Effectiveness

By implementing energy efficiency methods in homes, commercial buildings, government buildings, schools and industries is the most cost effective and constructive way to address the highly volatile prices, environmental concerns and global climate change that arises due to immense use of fossil fuel because as per the studies suggests, these sectors consumes for about 70% of the total developed energy and natural gas of US. By considering the following solution, this could help US in saving of approximately 50% or more of the expected electricity consumption in coming years, resulting,

billions of dollars saved in terms of energy bills along with also minimizing the significant amount of greenhouse gasses.

Several methods has been developed in order to measure the cost effectiveness of the system depending upon various parameters and scenarios. These tests are: Participant cost test (PCT), Program administrator cost test (PACT), Total resource cost test (TRC), Ratepayer impact measure test (RIM) and Societal cost test (SCT). All of these test has been summarize in TABLE 1, discussing all the parameters required to implement it.

TABLE 1
COST EFFECTIVENESS MEASURING TESTS

Test	Acronym	Key question answered	Summary approach
Participant cost test	PCT	Will the participant get any benefit from the measured life?	Detailed comparison of all the cost and benefits of the customer installing the measure.
Program administrator cost test	PACT	What will be the effect on utility bills?	Detailed comparison of program administrator approved cost and supply side resource cost.
Total resource cost test	TRC	Will the total cost of energy I the utility territory decrease?	Comparison of program administrator and customer costs to utility resource saving.
Ratepayer impact measure test	RIM	Is there any chances of the utility rates to increase?	Comparison of administrator costs and utility bill reductions to supply side costs.
Societal cost test	SCT	Is the utility, state, or a nation is better off as a whole?	Comparison of society's cost of energy savings and non-cash costs and benefit.

C. *Better Resource Management*

Resource management deals with a concept of achieving more while utilizing lesser. It is basically a criteria to manage the human usage of resources in such a way that while extracting benefits from it for current generation, we also might not forget the future ones. This grabs the attention of many researchers in a debate of sustainable development. One of the findings yields that certain resources are becoming extremely rare, so for us; in order to conserve it for future, have to utilize them cautiously and substitute these rare material with easily available or renewable one. The argument of concern is here that, to improve the productivity it is essential to minimize the impact on natural heritage to assimilate waste materials and energy [2]. Another researcher graham [3] states that, the civil industry is one of the major consumer of natural resources, therefore; number of initiative has to be pursued In order to create an ecological supportive buildings are focusing on increasing the efficiency of resource use. Such things can be carried out by designing of solar passive design which aim to reduce the consumption of non-renewable resources. Methodology that helps minimizing the material and construction wastage during building phase will also provide number of opportunities for recycle and reuse of material in order to implement better resource management. Resource conservation deals in variety conservation strategies which is showcased in Fig. *1*.

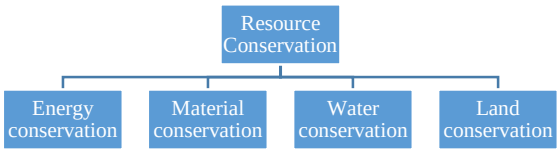

Fig. 1. Resource conservation

D. *Better Design*

Buildings, whether it's of commercial or residential use are of great important to human society. These are also an important sector where energy improvements around the world should be implemented as these are the major consumer of it. The building sector consumes energy in a measure to provide comfortless to its user in terms of lighting, heating, ventilation, cooling, automation, etc. all of these consumes energy. Typically the rate of energy consumed or utilized are found by dividing energy with the floor area of the building yielding in specific energy consumption rates. Thus, a better design is a term used to adapt a balanced approach to energy efficiency in structures than simply trying to minimize the energy consumption. These better designing often includes passive measure that inherently reduces the use of energy, such as better insulation or by minimizing the use of artificial lights in indoor conditions and allowing more and more natural light to take its place. A building's location also plays a vital role in regulating its temperature and illumination such as landscaping, trees and hills can be utilized to provide shade and block winds. Additionally, tight building design, such as installing energy sufficient windows, thermal insulation on walls, well-sealed doors can reduce the heat loss by 20 to 25 percent [4]. A study suggests that darker roofs can become 39^{o}C hotter than most of the reflective white painted roofs [5].

E. *Better Environment*

The growth of human society is directly has to deal with the relationship between the humans and their natural, social and built environments. This factor is also termed as human ecology, which broadens the concept of sustainable development by including the much needed domain of human health. Essential human needs, for example, the accessibility

to pure air, water, nourishment and sanctuary are additionally the biological establishments for development in sustainable way; [6] tending to general wellbeing hazard through interests in biological community administrations can be an intense and transformative drive for supportable advancement which, in this sense, reaches out to all species.

Ecological manageability concerns the indigenous habitat and how it bears and stays assorted and beneficial. Since regular assets are gotten from the earth, the condition of air, water, and the atmosphere are of specific concern. Environmental sustainability obliges society to outline exercises to address human issues while saving the life supportive networks of the planet. This, for instance, involves utilizing water economically, using sustainable power source, and concerned with sustainable material supplies

F. Better sustainability and performance

Energy sustainability is turning into a worldwide need, given the inescapable utilization of energy assets all around, the effects on nature of energy producing methods and on to nearby local and worldwide domains, and the expanding globalization of the world's economy. Energy is specifically connected to the more extensive idea of sustainability and influences the greater part of human advancement. That is especially apparent since energy assets drive much if not the greater part of the world's monetary movement, in essentially all financial segments, e.g., industry, transportation, private, business. Likewise, energy assets, regardless of whether carbon-based or inexhaustible, are acquired from the earth, and squanders from energy forms (production, transport, stockpiling) are often discharged to nature.

III. APPROACHES TO SUSTAINABLE ENERGY

A. Key step Approach

These days, corporates decision taking and action planning are decided on the basis of strategic approach to make the action or decision sustain longer; successfully. Otherwise, the action or plan can never be successful enough under the rapidly changing circumstances and soon corporate will find itself in an uncertain situation of fighting for its existence.

Key steps for successful strategic approach has been discussed in quite detail in this section, so that user could grasp its essence and take steps immediately without any further dely. It consist of following key steps:

1) Commitment of Top Management
2) Understanding the issues like
    a. Grasp current energy use
    b. Identify management strength and weakness
    c. Analyze stakeholder needs
    d. Anticipate barriers to implement
    e. Estimate the future trend
3) Plan and organize, including
    a. Develop a policy
    b. Make out a plan/program
4) Implementation
5) Controlling and monitoring performance
6) Management review

1) Commitment of top management

It is the most essential for the accomplishment of Energy Conservation exercises inside organizations or industrial facilities to have clear and authority duty of top administration – either the corporate top (senior) administration or manufacturing plant chiefs. The top (senior) administration should express responsibility towards the Energy Management (or Vitality Conservation) and carry on along this line- for example they should take a part in energy conservation activities themselves and encourage their staff as well.

2) Understanding the issue

Before attempting to make out any future projects or activity arranges, it is fundamental for the organization or production line administration to comprehend the present circumstance in a legitimate and precise way. This incorporates the status of their own operation as well as other significant data, for example, contenders' operation, conditions around the organization and their pattern in future, positioning the organization itself in the neighbourhood and in worldwide markets, and so on. The Key steps for this purpose are:

a) Grasp the current energy use

The information regarding current consumption of energy should be gathered through measurements, estimations or calculations of every individual unit under the premises of organization, with the classification on the basis of type of energy. The data should be collected regularly and arranged in daily, weekly, monthly or yearly manner depending upon the requirement and precision set by its stakeholders. Then the data should be analysed and a relation should be obtained between different operational modes and production scales. This data can also be utilized in the prediction of future trends.

b) Identify management strength and weakness

After the data collection, it should be compared with the pioneers or benchmarks in the industry. If such reference data is not easily available, then there historical data can be compared with the present data of their competitor so that right steps could be taken to get an edge over their competitor. Along with it, the strength and weaknesses of the company should also be evaluated considering the competitor situation in local and global market.

c) Analyse stakeholders needs

In an organization, stakeholders are basically top level Senior Managers, Directors, Staff/Engineers, and Workers/Operators. The need and expectation of these stakeholders must be taken into account so that everyone could adopt the changes caused by SEM easily and large benefits can be extracted out of it.

d) Anticipate barriers to implement

Designing an easy to implement and practically possible program also need consideration of expected barriers that could come along in its way of creating an organization that

follows all the steps of SEM and contributes towards its social, economic and environmental amenability. Some possible barriers could be:

- Insufficient support of top management
- Inadequate level of understanding and willingness of co-operation between multiple managers of same organization
- Untrained workforce
- Insufficient budget allocation for SEM implementation activities

e) Estimate the future trend

The future trend of energy demand could be estimated by using the historical data of the organization. This estimation enables the organization to increase or decrease in its power generation capabilities depending on rapidly changing circumstances of global market. It also provides a check and balance between the energy consumed and production of the organization for the particular period of time.

3) Plan and organize

Based on the analysis of previously collected data and understanding the position of company in local and global market and also identifying the strength and weakness of organization, the following step should be taken in order to design a relevant and good strategic plan to get a maximum out of this effort.

4) Implementation

The accepted plan should be enforced within an organization and all the organizational resources should be consumed in order to ensure smooth implementation of the plan. The responsible person or committee shall continue to work for the promotion of activities and training of workforce which is essential for the plan to survive.

5) Controlling and monitoring performance

After the implementation, all the processes should be closely monitored in order for it to work smoothly. If any problem arise, or any variance between estimated and observed value noted; then necessary steps should be taken in order to overcome and stabilize it.

6) Management review

After the plan or program has been completed, a report mentioning all the events, success and failures faced during its implementation should be submitted to top management. In it all the results should be analysed in quite detail for any good and bad points with possible recommendations. This report shall be utilized as a feedback for subsequent program. Thus all activities could be repeated to form a cyclic movement.

IMPLEMENTATION KEY STEP APPROACH

In order to implement SEM program effectively, key factors approach which is discussed in quite detail in our previous section should be utilized. The major step towards the implementation of SEM program in any organization is the Energy Audit. Energy Audit enables the organization to identify the problems or factors which could become a hurdle in the way of its implementation. Energy audit can be conducted by hiring an expert consultancy agency or by utilizing internal technical and trained staff.

1) Energy Audit

There are number of stages in energy audit process, each having its own importance. The process includes: Collection and analysis of data, site investigations, Cost and benefit analysis, Preparation of concise report, Creating an action plan for the project implementation and monitoring and controlling.

Energy audits acts as a foundation of developing an SEM program that will give an edge to the organization while creating more efficient operations. It also enables the analysis on where the most effective use of limited capital should be employed to achieve energy goals. Through Energy audit, specific type of system can be monitored throughout the operation, which can be optimized, modified or replaced based on the requirement. It also helps to identify the operations which yield greatest Rate of Investment (ROI), so that it could be modified and kept up to date in order compete with the changing circumstances of global market.

Monitoring systems energy consumption throughout the day and night cycle, and correlating it with the production delivers an important information regarding that systems efficiency. With newly introduced wireless energy monitoring technologies, this equipment's can be installed in a very cost effective manner on existing system. Data collection with every 15 minutes interval will be sufficient enough to estimate the efficiency of the system. The process cycle governing Energy Audit is shown is Fig. 2.

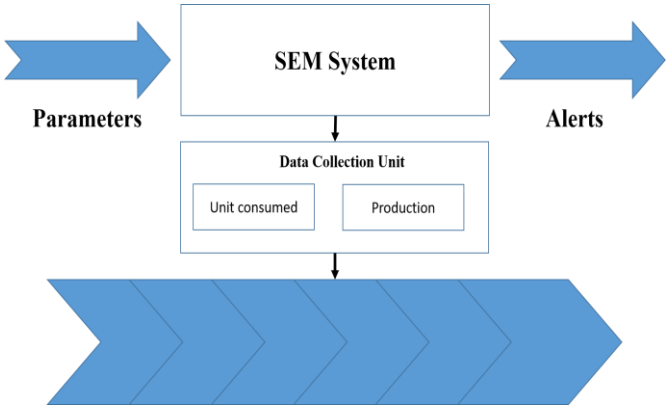

Fig. 2. Energy Efficient Operation [7]

2) Advanced monitoring and metering solutions

As discussed previously that to conduct a successful Energy Audit, monitoring devices needs to installed within premises in order to prepare a successful plan of action and correct estimation of future trends. These frameworks offer both modes, check of the utilities overwhelmed by a far reaching report, including droops and surges, and the capacity to power factor, harmonically disturbed waves and different parameters consistently. These solutions are adequate for obtaining metrics without any high capital investment or changing of existing system flows. It provides an important statistics of the

real time process on the basis of which decision can be taken for corrective actions. Whether it is effectively measuring a capacitor bank to enhance control elements, performing load shedding, or deciding squandered vitality utilization, Advance Metering offers many preferences basically from gathering precise information from dissimilar sources.

Hence, advanced metering is an approach to successful implementation of SEM on a distributed architecture and topology that will grow according to the requirement of organization. It will act as an essential strategic tool for optimization and evaluation of already installed process, operation or a system.

B. Six Sigma Approach to SEM

Concerns regarding the importance of conservation and effective utilization of energy are increasing day by day. As the evidence of the above statement it can be given that nowadays people are in a habit of switch off all the necessary equipment's, when not in used so as to use energy effectively. Bulk amount of energy generated by any nation has been consumed by the production or manufacturing industries to increase the countries GNP; therefore, certain approaches are required so that effective energy can be utilized by these sectors so as to increase their efficiency. The implementation of such systematic approach not only makes the nation industrialize and modern but is also effect the lifestyle of each individual of a society in a better perspective.

Cost associated with energy consumption is no longer considered as a minor component of total production expenditure. In-spite of its greater importance and influence, there are certain facilities which don't take its advantage by properly managing it and minimize its effect on expenditure sheet; which directly minimize the production costs. Facilities without proper power managing systems and determined energy managing approaches, don't have proper understanding regarding their energy usage and production ratio; such facilities cannot consume their resources to its fullest being efficient at the same time. While optimizing power monitoring investments, it is necessary to identify both intended application and prioritize energy consuming units within a facility.

Sustainable energy management is an effective tool which gives a certain edge to any facility over other (i.e. its competitor) by implementing it in terms of effective savings. These savings increases the GNP of overall nation i.e. if the manufacturer invests less on a product, they will further sell product in lesser amount to the end user. It also increases the purchasing power of the individual of any society; hence, larger the trade yields better GNP of nation. In addition to these advantages, SEM also minimizes the air pollution which we generate by burning fossil fuels. We cannot visualize it as we do when we starts a car but whenever we switch on a light, we generates some amount of pollution in power plant, which is then released in air in terms of carbon footprint and is a reason of global warming. The necessity of an hour is to utilize this all important form of energy is such a manner that it gives us advantage economically as well as ecologically.

The Six-Sigma is a proven approach in terms of quality management and implementation, as an extension to same principles this approach has been tested over the phenomenon of energy efficiency/conservation in number of facilities and there result came out to be unique and attractive. Six Sigma at numerous associations just means a measure of value that takes a stab at close flawlessness. Six Sigma is restrained, information driven approach and system for taking out deformities in any procedure – from assembling to value-based and from item to benefit.

The core objective of Six Sigma methodology is to develop a measurement-based strategy that primarily focuses in reducing the process variations and improve process outcomes. This objective is attained by implementing two Six Sigma sub methodologies namely: DMAIC and DMADV in a facility. DMAIC (Detect, Measure, Analyze, Improve and Control) mainly focuses on the improvement of existing processes falling below expected values; whereas, DMADV (Define, Measure, Analyze, Design and Verify) is methodology used to design new processes and system considering specific requirements. Energy conservation plan mainly developed keeping DMAIC process in consideration as it mainly used to implement on the existing processes to enhance efficiency.

Fig. 3. DMIAC Methodology (Six Sigma steps)

IMPLEMENTATION OF SIX SIGMA APPROACH (DMIAC METHODOLOGY)

a) Detect

The phenomenon of energy saving is considered to be more where its consumption is higher. Therefore, the key is to attack the larger energy consumer rather than implementing it and worrying about the minor one. From this point of view, while designing a plan for energy management first target larger energy consumer within a facility i.e. heating systems, cooling systems, lightning etc. Those points also need to be detected in a process where energy has been wasted or exhausted for effective and long lasting saving. In order to detect/define such points and elements in a process, traditional approach of installing metering gives snapshot data of energy consumption which is not sufficient enough, for effective monitoring real time data logging devices need to be installed. There are certain rules to install power monitoring devices which are given below:

1) Advanced monitoring systems need to be installed with main electrical switchgear whereas less sophisticated metering devices should be deployed to each of the identified bulk energy consumer. The

advantage of installing advance monitoring system with main grid is that it will not only monitor the electrical parameters of the facility but also the power quality or power factor it is receiving. This approach enables its user to monitor basic electrical parameter and on the same time grasping the firsthand knowledge of the quality of power facility is receiving through electric utility.

2) As discussed, continuous monitoring of large loads allows to identify and predict accurate energy savings; therefore, the more the monitoring points will be, the better electrical model can be generated for statistical predictions.

b) Measure

After identifying/detecting which load to measure, accurate measurement devices need to be installed in order to do quantitative analysis. Properly installed and verified measuring system could be a valuable asset for any organization. Annual energy consumption and production are the major concerns of an organization. An electrical measuring system could contain one or discrete points which are interconnected on a single station so as to enable a single user to monitor all the happening of the at a single point. An efficient measuring system contains three major components: metering devices to measure data, application software to manage, accumulate, display data and matched communication module in order to link metering devices with application software.

This measuring system should be robust enough in order to work and gather real-time data 24/7. This continuous extraction of important information mostly with the frequency of every 15 minutes enables the user in correct decision making. Also, this will give accurate information regarding how much energy is consumed, in which part of the day the consumption is greater and what unit/load consumes larger energy. This knowledge plays a vital role in reducing the energy consumption and increase the efficiency of the process.

c) Analyse

Two type of analysis is mostly done in order to come-up with an accurate energy management plan which is of energy consumption and quality. All the gathered data is then analysed with respect to these two segments and parameter of interest are current and voltage consumption during the start-up of load, power factor and energy consumption. These observed parameters then can be compared with the actual in order to identify deviation of each load. These analysis helps the production engineer with energy consumption pattern for planning shift activities such as production rates reducing production break-downs, maintenance engineer to check that whether the equipment is due for maintenance or not and planners to plan appropriate sizing of facility.

d) Improve

This analysis is then used in creating an appropriate energy management strategies for optimum and efficient plant operation, this includes:

1) Enabling the organization to predict the energy consumption pattern in manufacturing and production facilities with respect to any season, part of the day or year.
2) Standardize the energy consumption patterns for different points, loads or facilities within the plant.
3) Enable to shift the operations in the off-peak times, this is mostly suitable for the countries in which load shedding is commonly done.
4) Prediction of possible energy interruption during the operation which could affect the process a great deal.
5) Automatically improves power factor by adding a capacitor banks if correct prediction of its arrival can be made.

e) Control

After taking steps to improve the power efficiency of the system, certain controls are needed to make it long lasting. The remarkable work in this field enable the development of devices like adjustable speed control motor drives and shunt capacitors for power factor correction and reduce losses.

IV. CASE STUDY

Energy efficiency program at Doubletree Hotel Sacramento, California

Doubletree hotel is located in Sacramento, capital city of state of California, United States. Size of hotel is 680,000 ft^3 with annual electricity consumption of about 7,451 MWh. This case study discusses the steps taken by the hotel management for controlling the energy cost of 680,000 ft^3 size hotel and conference centre with multiple HVAC systems. This is not a simple undertaking to do particularly in condition of California, where in the course of recent years, power costs stayed well over the national normal. With the additional danger of planned power outages, value unpredictability, and the potential for ongoing vitality estimating, controlling vitality costs has turned out to be basic for the Doubletree Hotel and other California organizations.

The hotel met this challenge by implementing an aggressive energy management strategy using advanced automation techniques. The hotel administration installed energy management system with advanced metering devices in their hotel to monitor their daily electricity needs. This real-time energy information system (EIS) allows them to reduce load of a particular section of the hotel when needed and improve the efficiency of energy using equipment's and systems. Through this EIS system is linked to hotel interval meter. Facility operator keep a careful watch on system energy consumption throughout the day from their PC. As the demand reaches its peak levels, facility operator can start shedding the load so as to stop the excessive demand charges. The Doubletree uses their EIS to target numerous HVAC systems from a central location, and immediately see the effects on overall demand.

The process flow of EIS system of Doubletree is given below in Fig. *4*, the HVAC system of hotel includes a 150tons centrifugal chiller and a 100ton steam absorption chiller installed to serve 3 guest wings and the main building,

150ton centrifugal chiller serving the ball room, fifteen 10tons chiller packages to serve office space, retail space and lounge, three 100tons air chiller to serve three back wings and four swamp cooler to serve in kitchen and pantry. The EIS system strategically generates direct digital control signals to monitor and control water loop temperatures, outside air intake and fan speed. The facility manager can set the parameters of operational equipment's using EIS graphical user interface (GUI). If EIS sends a notification to curtail load, an operator first views energy use data to see which systems are drawing the most load, and then uses the EIS commands to shed chiller or fan loads accordingly. Lighting loads, which are controlled manually, are also considered for curtailment, depending on occupancy levels.

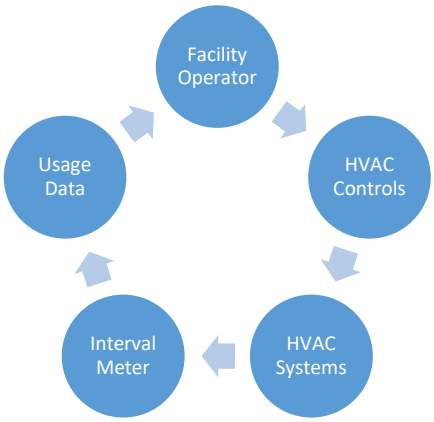

Fig. 4. Process flow of Doubletree energy efficiency strategy

Furthermore, the hotel's EIS is connected in a modem operated interval meter and Enter Link, a software through which operator can dial into interval meter and extract reading of energy usage after every 15 minutes interval. This facility not only enable them to predict what their utility bill going to be each month but also generate report and graphs in number of format for comparison and analysis.

A. Results and analysis

With these steps mentioned above, hotel management successfully reduces their load by 11% in 2001. As a result, they were able to hold electricity cost increases to 2.5%, despite a 15% increase in annual energy rates and cut energy use by more than 800Mwh [8].

V. CONCLUSION

By sustainable energy it is meant to extract energy from such sources which are present in bulk quantity and by utilizing them for our purpose they won't get depleted. It can also be defined as the development that is sufficient to meet our current need, without compromising the ability of future generations to meet their own. One of the reason for which development of sustainable energy systems recommended throughout the world is its characteristics of not to harm or affect the environment and most importantly the ozone; Moreover, is available free of cost throughout the day-cycle. All renewable forms of energy like: geothermal, solar, tidal, biomass and wind are known as sustainable as they are not only stable but also available naturally in bulk throughout the day and can easily be converted and stored after the successful study and inventions of different modules like lead acid battery, chillers, methane controlled chambers, turbines etc. In this chapter, we will independently study all of the sources of sustainable energy and their individual applications as well as significance.

Beside material cost, energy cost is a major pressure factor for several organizations and manufacturers. A sound and easy to implement business strategy can yield more production stability by reducing cost. In order to work in profit and with efficiency, modern operations largely depend on the low cost of energy it consumes. Energy conservation and independence are also considered as major strategies for creating a competitive advantage in business. Realizing the fact, that energy management could play a vital role in addressing social, economic and environmental concerns, organization are readily adopting these practices to minimize the risks. Overall, energy efficiency and management practices are among the most important option to increase the profit of organization as well as to reduce their dependencies on highly volatile fossil fuel prices.

Prove of concept have been give through a case study of hotel double tree Sacramento; where these approaches and practices have been practically implemented in their normal routine and it yields for about 11% decrease in their annual electricity bill. Thus utilizing these all important resources efficiently and effectively.

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