CHAPTER 1
INTRODUCTION

1.1. ENERGY MANAGEMENT: AN OVERVIEW

Energy is an integral part of today’s modern life. It has become the blood of our day to day life. But it is not free. It comes at a monetary price but more than that it comes at environment cost too.

It is very difficult to think about our modern life without energy. But the generation of energy requires natural resources which are depleting day by day. On the other side, use of energy is increasing exponentially. In developing nation like India, about 49% of total commercial energy is consumed in industries and utilities like Compressed Air, Air Conditioning, Steam, Hot water, Electrical systems, fuel, water system consumes substantial part of total energy in these industries.. Figure Number 1.1 shows, sector wise energy consumption for the year 1999-2000.

**Figure No 1.1: Sector wise Energy Consumption (1999-2000)**

Source: Bureau of Energy Efficiency, India.

Thus the need to improve and maintain energy efficiency in industrial utilities is strongly felt to survive in present scenario of rising energy costs and volatile energy markets and to gain competitive advantage. On the other side, consumption of energy
resources in industries leads to atmospheric pollution and damages environment. Application of energy efficient technologies to improve energy efficiency (i.e., reductions in energy per unit of output) in industries are often suggested as a means of reducing carbon emissions. In many cases where climate change is not a concern; improvements in energy efficiency will pay for themselves through reductions in energy costs.

In India, per capita Energy Consumption is very low. Being a developing country, it needs to achieve Economic Growth by increasing its pace of development through industrialization. There are two options to match the pace of industrial development. First one is to produce more and more industrial energy which is quite difficult considering depleting natural resources and second one is to reduce the consumption of energy by improving energy efficiency in industries especially in utilities. The research focuses on reducing energy consumption of industrial utilities through energy efficient technologies. It also focuses on barriers to energy efficiency in industries and training needs of the employees for the effective energy management in industries.

Pune is a hub of automobile industries in India and one of the most polluted city in the state. This study deals with the energy management in utilities of automobile industries in Pune manufacturing passenger cars. The researcher studied the status of energy management in these industries with respect to energy efficient technologies adopted and barriers in their adoption, performance assessment of utility equipment, utility costing, and training needs of employees on energy management.

We have limited fuels available on earth. Our demand for energy is increasing day-by-day. It is possible that someday, most of fuels will be exhausted, and we will have to switch over to alternate energy. At present consumption levels (world) are - Crude oil will last only for 45 years. Gas will last for 65 years. Coal will be finished in nearly 200 years.¹

¹BP Statistical Review of World Energy, June 2004
It is estimated that Industrial energy use in developing countries constitutes about 45-50% of the total commercial energy consumption. Much of this energy is converted from imported oil, the price of which has increased tremendously so much so that most of developing countries spent more than 50% of their foreign exchange earnings. Not with standing these fiscal constraints, developing countries need to expand its industrial base like us if it has to generate the resources to improve the quality of life of its people. The expansion of industrial base does require additional energy inputs which become more & more difficult in the present scenario. (Naik Irawati, Prof. Mrs. S.S. More, Himanshu Naik )

In response to the wave of challenges related to energy use, some industries around the world have reduced energy intensities by adopting and developing energy efficient technologies and management strategies. This is a justification for their high energy end-use and high contribution to energy related environmental problems. By doing so, industries have not only gained improvement in environmental protection, but also gained economic and social dividends. Numerous studies have highlighted the tremendous gains of implementing industrial energy efficiency and management measures. Notably, some of these studies reveal that greater savings can be realized in developing countries.

Considerable untapped potential exists for curbing wasteful use of energy estimated to be of the order nearly 30 per cent of the total consumption of commercial energy. The size of energy efficiency markets growing @ 10% annually in India is estimated to be in the range of Rs. 200 to Rs. 300 billion. In spite of many efforts and benefits of energy efficiency, several technical, financial market and policy barriers have constrained the implementation of energy efficiency projects. (Shekhar Shashi, 2002) 

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2 Naik Irawati, Prof. Mrs. S.S. More, Himanshu Naik, “Scope of Energy Consumption & Energy Conservation in Indian auto part manufacturing Industry”, ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online)

3 Shekhar Shashi, 2002, Promotion of Energy Conservation in the country, IIPEC Programme on 22nd September 2002 at M/s. Shree Cement, Beawar
Indian industry uses energy more intensively than is the norm in industrialized countries. While selected modern Indian units often display very high efficiency that approaches world best practice levels, the average intensity lags world best levels. Indian industry has undergone a transformation since 1991, the year the economy was opened to foreign investment and competition. Energy per unit of valued added in the industrial sector has declined since then. However, there still remains considerable scope for continued improvement of energy efficiency in Indian industry, and for learning from both worldwide and Indian best practices. (Sathare Jayant, Lynn Price, Stephane de la Rue du Can, David Fridley, 2005)

Considering potential for energy savings especially in industries, fastly depleting energy resources and the harmful effects of energy consumption on environment, researcher has taken this study to understand the energy efficient measures adopted by the industries and barriers in their adoption. This study incorporates the investigation of barriers for the implementation of energy efficient technologies in Industrial utilities to shed light on the rationale for non-adoption of cost effective industrial energy efficient technologies.

India is one of the fastest growing modern economies of the world today. With economic growth rates ranging between 8% and 9% in the last 6 years and a double digit growth rate target for next decade, the Indian economy has become an energy guzzler. As per the global environment facility (GEF), industry remains the largest consumer of energy in the Indian economy; accounting for over 50% of total primary energy consumption in the country. There are estimated 13 million Micro, Small, and Medium-sized Enterprises (MSME) contributing to around 45% of manufacturing output, and employing more than 40 million people. Most of energy intensive MSMEs depend on inefficient equipment, technology and operating practices, leading to high energy consumption and significant CO2 emissions.

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Indian industries are lagging in application of Energy Efficient technologies for improving energy efficiency because of the various reasons. Specific energy consumption is very high in Indian industries.

The main reasons for higher specific energy consumption in Indian industries are:
1) Obsolete technology
2) Lower capacity utilization
3) Causal metering and monitoring of energy consumption
4) Lower automation
5) Raw material quality and poor handling
6) Operating and maintenance practices
7) Lack of knowledge/awareness among the employees

So, the technology upgrades, Re-engineering and continuous evaluation, Self-knowledge & Awareness among the masses is basic step towards energy conservation program in any industry. It is strongly required to monitor energy utilization on continuous basis and relate it to specific energy consumption. This research analyses the status of training programs on energy management conducted in the organization and needs of the employees to improve their technical capabilities and awareness about energy management in passenger car manufacturing automobile industries in Pune. It provides comprehensive information about the industrial energy culture of these industries derived from both primary and secondary data sources.

Since, the substantial share of energy resources is consumed in generation, distribution and utilization of electrical and thermal utilities, improving energy efficiency in industrial utilities is the very first step in Energy Management. Hence it calls “Management of Energy in industrial utilities”.

Air compressors account for significant amount of electricity used in Indian industries. Only 10-30% of energy reaches the point of end-use, and balance 70-90% of energy of the power of the prime mover being converted to unusable heat energy and to a lesser extent lost in form of friction, misuse and noise. The compressed air system is not only
an energy intensive utility but also one of the least energy efficient. Lighting is an essential service in all the industries. The power consumption by the industrial lighting varies between 2 to 10% of the total power depending on the type of industry. Pumps and pumping systems consume about 10% of the total electrical energy produced in the world. Air conditioning and refrigeration consume significant amount of energy in buildings and in process industries.6

These electrical and thermal utilities are not only energy intensive utilities but the least energy efficient systems too. Over a period of time, both performance of these utility equipment and utility system reduces drastically. The causes are many such as poor maintenance, wear and tear etc. All these lead to additional utility Equipment installations leading to more inefficiency. Therefore, a periodic performance assessment of these utility Equipment with a standard procedure is essential to minimize the cost of energy. This doctoral study also deals with the status of performance assessment of major utility equipment at a periodic intervals with standard procedure.

1.1.1. Definition of energy management

Many definitions have been offered for “energy management”. One definition that captures the key principles is as follows:

“The judicious and effective use of energy to maximize profits (that is, minimize costs) and enhance competitive positions.”7 Therefore, any management activity that affects the use of energy falls under this definition. The primary objective of energy management is to maximize profit and minimize costs by optimizing energy procurement and utilization, throughout the organization to minimize energy costs without affecting production and quality and to minimize environmental effects.

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Among the practices that arise from the above definition are the following:

**Eliminate Waste:** Ensure that energy is used at the highest possible efficiency.

**Maximize Efficiency:** Utilize the most appropriate technology to meet organizational needs.

**Optimize Supply:** Purchase or supply energy at the lowest possible cost.

Energy management practices may vary from simple maintenance and operational activities that ensure equipment and systems use energy efficiently and effectively, to capital intensive installation of new, more efficient technology.

Some desirable sub-objectives of energy management programs include:

1) Conserving energy, thereby reducing cost
2) Cultivating good communications on energy matters
3) Developing and maintaining effective monitoring, reporting, and management strategies for efficient energy usage
4) Finding new and better ways to increase returns from energy investments through research and development
5) Developing interest in and dedication to energy management program from all employees.

**1.1.2. Motivation to energy management**

There are many motivational forces for energy management presently acting on the industrial sector. They are:

a. **Competitiveness:**

   Although energy cost may constitute a relatively small part of total operating cost, for many industries, it is one of the most manageable resources among labor and material. Reductions in energy consumption and thereby reducing energy cost are very vital for any industry to remain competitive.

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b. **Short Falls in power supplies:**

Due to limitations in power supply infrastructures, many industries face power supply problems in terms of reliability and quality of the power supply and increasing energy demand and industrialization have led to predictions of a serious supply shortfall.

c. **Environmental Management Systems**

In certain parts of the world, especially in Europe, ISO 14001 standard on environmental management is increasingly becoming a requirement for trade. Energy management is an important component of environmental management and waste reduction strategies, and features significantly in ISO14001.

d. **Global Climate Change:**

The global climate is changing because of human activity, and that one of the major causes of climate change is the emission of Greenhouse Gases (GHG), principally CO2, into the atmosphere from the combustion of fossil fuels. Since fossil fuels, directly or indirectly, are important energy sources to industry, there is international pressure to reduce GHG emissions by reducing energy consumption.

1.1.3. **Energy is a Manageable Expense**

For many organizations, energy (electricity, coal and fuel), labour and materials are the top three operating expenses. They have realized as much as 25% savings in energy costs by implementing an energy management program. On the basis of the amount spent, energy often ranks third on the list behind labour and materials. However, if we rank these cost centres in terms of the potential for savings, many companies find that energy moves to the first priority position. In fact, as shown in figure No. 1.2, energy management would deliver about twice the savings that materials management would and five times what labour cost management offers.
Figure 1.2, Energy is a manageable expense — perhaps the most.

Source: www.energy.gov.za/EEE/Projects/IndustrialEnergyManagement

1.1.4. The Dimensions of Energy Management
Industries that successfully manage their energy use indicate that technological solutions alone do not achieve maximum energy savings, and are less likely to be sustained in the long term. Energy management has the greatest impact when organisations address the following three dimensions as shown in Figure No. 1.3.

Figure 1.3: Dimensions of Energy Management
(Adapted from Dollars to Sense Energy Master Planning Workshop, Natural resources Canada.)

Source: www.energy.gov.za/EEE/Projects/IndustrialEnergyManagement
a. Technical
The energy consuming devices and systems that use energy efficiently, or inefficiently.

b. Organizational
The structure and management systems that can support the achievement of energy efficiency goals.

c. Human behavioral
The personal values, attitudes and practices of individuals in the organization that impact on energy use.

1.2. HISTORY OF ENERGY MANAGEMENT

The gulf war came as an eye opener for all developed and developing countries. It was then the first time that the nations importing petroleum products felt the shock when the petro-nations demanded higher price. The big change introduced by the 1973 "energy crisis" was the realization that energy sources might not keep pace with mankind's ability to use energy. This was not a new concept for specialists in energy resources, but it was new as a popular idea. Stated differently, the supply of energy was no longer viewed as something that was always ahead of demand. Instead, the supply of energy, although still vast, was now viewed as lagging demand.

The energy crises of 1973 forced the world to look for an alternative arrangement to ensure energy sufficiency. This need obviously pointed at improvement of energy efficiency. The concept changed to ‘More efficiency, more productivity and reduced production cost’. This promised an immediate, long term and multi-faced solution to the problems immerging from increased energy demands against short supplies. Energy management has since become the key word for any profitable industrial unit. Besides now the ‘energy’ accounts for a sizable share in the cost of production in most of the industries.
As a result of this, positive trends have been noticed over the past decade in the energy use pattern the world over countries like the United States, Japan and France have managed to raise their GNP while maintaining the same energy consumption levels. In many cases while the GNP has gone up the energy consumption has exhibited reducing trends. Introduction of energy efficient technologies and effective energy management has made this possible. Efficiency of energy utilization needs to be a continuous activity as there is lots of unproductive energy utilization generally observed in Indian industrial sector.

These are significant generalizations that we can make about the modern era of energy conservation, thus far: The 1970’s were a time of great ferment and rapid learning. The 1980’s was a period in which many bad ideas from the 1970’s collapsed. The 1990’s was a time of stagnation and information loss. The new millennium restores interest in energy conservation, largely under the banner of environmental protection. During the first part of the modern era, energy conservation was independent of environmental protection. Then, they were seen as conflicting issues. Now, they are seen as complementary issues. Previously, energy efficiency had been a technical aspect of designing equipment, systems, and buildings. In 1973, efficiency metamorphosed into "energy conservation," which emerged as a distinct field of interest, rather than continuing to be a subsidiary engineering issue. Energy conservation became a single freestanding issue, independent of the many technical areas to which efficiency applies specifically. This single-issue nature of energy conservation became a dominant factor in information about energy conservation from that time until the present.

The world is moving towards a sustainable energy future with an emphasis on energy efficiency and use of renewable energy sources. A finite planet cannot support infinitely increasing consumption of resources and hence the motto of the present time must be to “REDUCE, REUSE, and RECYCLE.”

Energy conservation is an issue with many aspects that continue to evolve. There have been major areas of technical improvement. There are also important areas in which there has been virtually no improvement, and hence, most of the potential of energy
conservation still remains to be tapped. To identify these potential areas for energy savings by describing the present level of energy management in industries induced this study.

In this continuously evolving process of energy management, the present study is very important which adds information to the body of knowledge of energy management. The study will help researchers, policy makers, industries to achieve their ultimate objective of energy conservation and energy efficiency.

1.3. NEED FOR ENERGY MANAGEMENT IN INDIA

Increasing energy demand in India is a drain of the national economy. Besides, it is a major factor hindering the competitiveness of basic Indian industries in the global market. Thus, energy conservation is equally important for the nation and industrial firms. Electrical power is one of the scarce resources in our country. Generation of electricity is very capital intensive. 1 MW of power generation costs approximately Rs. 4 crores because of the low plant load factor and high transmission losses prevalent in the country. The installed capacity of power station has to be therefore, 2.2 times the electrical load.

It has been estimated that nearly 25,000 MW can be saved by implementing end-use energy efficiency and demand side management measures throughout India. Efficient use of energy and its conservation assumes even greater importance in view of the fact that one unit of energy saved at the consumption level reduces the need for fresh capacity creation by 2 times to 2.5 times. Further, such saving through efficient use of energy can be achieved at less than one-fifth the cost of fresh capacity creation. Energy efficiency would, therefore, significantly supplement our efforts to meet power requirement, apart from reducing fossil fuel consumption.

The economic development of a country is often closely linked to its consumption of energy. Although India ranks sixth in the world as far as total energy consumption is

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9 Maharashtra Energy Development Agency (MEDA)
concerned, it still needs much more energy to keep pace with its development objectives. India’s projected economic growth rate is slated at 7.4 per cent during the period 1997-2012. This would necessitate commensurate growth in the requirement of commercial energy, most of which is expected to be from fossil fuels and electricity.

India’s proven coal reserves may last for more than 200 years, but the limited known oil and natural gas reserves may last only 18 years to 26 years, which is a cause of concern. The continued trend of increasing share of petroleum fuels in the consumption of commercial energy is bound to lead to more dependence on imports and energy insecurity.

India’s energy intensity per unit of GDP is higher as compared to Japan, U.S.A. and Asia by 3.7 times, 1.55 times and 1.47 times respectively. This indicates inefficient use of energy but also substantial scope for energy savings. The increasing global trade liberalization and growing global competition have made productivity improvement, including energy cost reduction, an important benchmark for economic success. Therefore, a paradigm shift in our approach to energy policy issues is needed – a shift from a supply dominated one to an integrated approach. This integrated approach would have to incorporate a judicious mix of investment in the supply side capacity, operational efficiency improvements of existing power generating stations, reduction of losses in transmission and distribution, end-use efficiency and renewable technologies.

The policy goals and concepts would have to be shifted from “energy conservation to “energy efficiency” and from “energy inputs “to the “effectiveness of energy use “and “energy services Creation of new power generation capacity is costly and necessitates long gestation period whereas energy efficiency activities can make available additional power at comparatively low investments within a short period of time.”

The present study is focused on the various ways to improve energy efficiency in industries to enable them to save energy.

India has limited sources of conventional energy and is highly dependent on the imports for coal and oil. A lot of the nation’s wealth goes into the import of coal and oil for
energy. According to the reports of World Resources Institute (WRI) India’s energy
demand will more than double in 2030. The volatile situation in oil exporting area raises
concerns of energy security rather than just price volatility. For a nation like India
where internal resources are limited and external resources are costly and uncertain, the
future lies in renewable energies and energy efficiency.

India relies on indigenous coal, and to a lesser extent oil, to meet its energy demand. While the country has had large reserves of coal, it now imports over 15% of its coal supply, relies on imported oil for more than 75% of its oil needs, possesses limited natural gas reserves while importing 30% of total supply, and faces chronic electricity shortages. The gap between electricity supply and demand in terms of both capacity (i.e. kW) and energy (i.e. kWh) has been shifting annually in India. The extent of shortage reported by India’s Ministry of Power (MOP) in its Annual Report for 2007-08, has increased from 7% to 10% (energy) and from 11% to 17% (capacity) in the last five years.10

1.4. ENERGY STATISTICS OF INDIA11

a. The Indian economy has experienced unprecedented economic growth over the
last decade. Today, India is the ninth largest economy in the world, driven by a
real GDP growth of 8.7% in the last 5 years (7.5% over the last 10 years). In
2010 itself, the real GDP growth of India was the 5th highest in the world. This
high order of sustained economic growth is placing enormous demand on its
energy resources. The demand and supply imbalance in energy is pervasive
across all sources requiring serious efforts by Government of India to augment
energy supplies as India faces possible severe energy supply constraints.

b. A projection in the Twelfth Plan document of the Planning Commission
indicates that total domestic energy production of 669.6 million tons of oil

10 http://www.powermin.nic.in/indian_electricity_scenario/policy_initiatives.htm
11 Energy Statistics, 2013 (Twentieth Issue), Central Statistics Office, Ministry of Statistics and
Programme Implementation, Government of India.
equivalent (MTOE) will be reached by 2016-17 and 844 MTOE by 2021-22. This will meet around 71 per cent and 69 per cent of expected energy consumption, with the balance to be met from imports.

c. India’s energy basket has a mix of all the resources available including renewable. The dominance of coal in the energy mix is likely to continue in foreseeable future. At present India’s coal dependence is borne out from the fact that 54 % of the total installed electricity generation capacity is coal based and 67% of the capacity planned to be added during the Five year Plan period 2007-12, is coal based. Furthermore, over 70 % of the electricity generated is from coal based power plants. Other renewable such as wind, geothermal, solar, and hydroelectricity represent a 2 percent share of the Indian fuel mix. Nuclear holds a one percent share.

d. The share of Coal and petroleum is expected to be about 66.8 per cent in total commercial energy produced and about 56.9 per cent in total commercial energy supply by 2021-22. The demand for coal is projected to reach 980 MT during the Twelfth Plan period, whereas domestic production is expected to touch 795 MT in the terminal year (2016-17). Even though the demand gap will need to be met through imports, domestic coal production will also need to grow at an average rate of 8 per cent compared to about 4.6 per cent in the Eleventh Five Year Plan. The share of crude oil in production and consumption is expected to be 6.7 per cent and 23 per cent respectively by 2021-22.

e. In 2011-12, India was the fourth largest consumer in the world of Crude Oil and Natural Gas, after the United States, China, and Russia. India’s energy demand continued to rise in spite of slowing global economy. Petroleum demand in the transport sector is expected to grow rapidly in the coming years with rapid expansion of vehicle ownership. While India’s domestic energy resource base is substantial, the country relies on imports for a considerable amount of its energy use, particularly for Crude Petroleum.
f. Combustible renewable and waste constitute about one fourth of Indian energy use. This share includes traditional biomass sources such as firewood and dung, which are used by more than 800 million Indian households for cooking.

g. India faces a significant challenge in providing access to adequate, affordable and clean sources of energy, especially cooking fuel to a large section of the population, most of who live in rural areas. As per the 2011 Census, almost 85% of rural households were dependent on traditional biomass fuels for their cooking energy requirements. National Sample Survey 2009-10 reveals the continued dependence on firewood in rural areas for cooking, with percentage of households depending on firewood remaining at 76.3% in 2009-10 – a drop of only 2 percentage points since 1993-94 – even though the percentage using LPG has increased from about 2% to 11.5% over the same period. On the other hand, the incidence of dependence on firewood for cooking in urban areas has fallen from about 30% to 17.5% between 1993-94 and 2009-10 – a drop of more than 12 percentage points – and the incidence of dependence on kerosene has plunged from 23.2% to 6.5% during the same period – a 72% fall, while the incidence of urban households using LPG has more than doubled from under 30% to 64.5%. In other words, the growth in prevalence of use of LPG in urban areas has been balanced by a decline in use of kerosene, in the first place, and firewood and chips, in the second. In rural areas, the rise in LPG use has been mainly at the expense of dung cake, followed by kerosene and ‘other’ sources. Further, as per the NSSO Reports (55th, 61st and 66th Rounds), there has been an increase in biomass fuel use in terms of absolute quantity consumed over the past decade among rural households. This is an area of concern given the considerable health impacts of burning biomass fuels apart from being a hindrance to achieving developmental goals, i.e. ensuring a minimum standard of living and provisioning of basic minimum needs. Thus, a transition to cleaner forms of energy in terms of access to electricity and other modern energy forms would have implications not only on energy security, but also with respect to enabling gender equality and bring about greater development and social progress.
h. The state of preparedness of the country for generation of the energy it requires and the quality or efficiency of the technology used in the generation can be well analyzed by the indicators of installed capacity and capacity utilization, respectively. The power sector in India had an installed capacity of 236.38 Gigawatt (GW) as of March 2012 recording an increase of 14% over that of March 2011. Captive power plants generate an additional 36.5GW. Thermal power plants constitute 66% of the installed capacity, hydroelectric about 19% and rest being a combination of wind, small hydro-plants, biomass, waste-to-electricity plants, and nuclear energy. India generated about 855 BU electricity during 2011-12 fiscal.

i. As of March 2012, the per capita total consumption in India was estimated to be 879 kWh. India's electricity sectors is amongst the world's most active players in renewable energy utilization; especially wind energy. As of March 2012, India had an installed capacity of about 24.9 GW of new and renewable technologies-based electricity. During the Eleventh Five Year Plan, nearly 55,000 MW of new generation capacity was created, yet there continued to be an overall energy deficit of 8.7 per cent and peak shortage of 9.0 per cent. Resources currently allocated to energy supply are not sufficient for narrowing the gap between energy needs and energy availability.

j. As per the 2011 Census, 55.3% rural households had access to electricity. However, NSS results shows that in the year 1993-94, 62% households in rural India were using kerosene as primary source of energy for lighting. In 2009-10, on the other hand, 66% households were found using electricity for lighting. Thus electricity has, during the intervening years, evidently replaced kerosene as the most common fuel used for lighting by rural households. This substitution of kerosene by electricity appears to have been most rapid during 1993-94 to 1999-2000, when about 11% households seem to have switched to electricity. The substitution appears to have slowed down since then, with 8% more households switching over to electricity during the seven or eight years after 1999-2000, and picked up pace again thereafter, with another 9% of rural households added to
the category of electricity users since 2006-07. Indeed, this may widen as the economy moves to a higher growth trajectory. India’s success in resolving energy bottlenecks therefore remains one of the key challenges in achieving the projected growth outcomes. Further, India's excessive reliance on imported crude oil makes it imperative to have an optimal energy mix that will allow it to achieve its long-run goal of sustainable development.

k. Energy exploration and exploitation, capacity additions, clean energy alternatives, conservation, and energy sector reforms will, therefore, be critical for energy security. Energy conservation has also emerged as one of the major issues in recent years. Conservation and efficient utilization of energy resources play a vital role in narrowing the gap between demand and supply of energy. Improving energy efficiency is one of the most desirable options for bridging the gap in the short term.

1.5. SOURCES AND USES OF ENERGY IN INDIA

India uses all the main sources of energy such as coal, lignite, crude oil, petroleum products, natural gas, hydropower, nuclear power, and wind.

a. Coal and lignite

The Indian economy is highly dependent on coal. In the financial year 2010/11, coal contributed to about 52.87% of the total primary energy consumption in the country. In energy terms, India accounts for 8% of the world coal consumption and is the third largest consumer of coal in the world after China and USA.

The following figure Number 1.4 shows the distribution of coal consumption in the world for the year 2012. According to the figure, China has the highest coal consumption in the world followed by USA (14%) and India (8%). However rest of the word consumes balance 29% of the total coal.
b. Oil and gas

After coal, oil and gas are the next most important fuels in India. Oil and gas account for 39.3% and 9% of the primary commercial energy supply in India, respectively (TERI 2012). In terms of consumption of petroleum products, the transport sector is the largest and the Fastest-growing consumer in India, accounting for 39% of petroleum products consumed, followed by residential and commercial and industry sectors. Consumption of petroleum products has increased by 17.4% since 2006/07. India has the fifth largest refining capacity in the world and is emerging as a major refining hub.

c. Power

Out of the total installed capacity, the highest share is contributed by the state sector (43%), followed by the central sector (29.8%), while the private sector contributed the rest (27.1%). But capacity addition in the country has always fallen short of the planned targets. The capacity addition target set for the Eleventh Five-year Plan was 78 700 MW, but the capacity addition was only 53 922 MW, having a slippage of about ~25 000 MW approximately (CEA 2011).
The following Figure No. 1.5 shows Electricity Generation by Source, as on 31.03.2012.

Figure Number 1.5 Electricity Generation by Source, as on 31.03.2012

Source: CEA, 2011.

d. **Renewable energy sources**

Renewable energy comprises small hydropower, wind, solar, and geothermal energy and modern biomass energy. India was among the first countries in the world to set up a separate ministry for non-conventional energy resources in the early 1980s. As on 31 August 2012, grid-interactive renewable power contributed about 25858 MW of electricity, which is around 12% of total installed capacity in the country and off-grid/captive power contributing to about 757 MW. Wind power consisted of 17 967 MW, followed by small hydropower at 3434 MW, biomass at 3319 MW, solar at 1044 MW, and waste to power at 94 MW.

e. **Nuclear power**

There has been an interest in nuclear energy because of increasing fossil fuel prices and concerns over energy security and rising GHG emissions. India has a
largely indigenous nuclear power Programme and expects to have 20 000 MW of installed nuclear capacity by 2020 and 63 000 MW by 2032.

1.6. SALIENT FEATURES OF ENERGY DEMAND AND SUPPLY IN INDIA

1.6.1. Energy indicators

a. As per estimates by the International Energy Agency, fossil fuels accounted for 73% of the primary energy supply in India in 2010/11. This percentage was 29.9% in low-income countries and 80.7% in middle-income and high-income countries that are members of the Organization for Economic Cooperation and Development (OECD).

b. Per capita energy consumption in India in 2010/11 was about 500 kilograms of oil equivalent (kgoe). The annual increase from 2009/10 to 2010/11 was 3.65%.

c. The gross domestic product (GDP) per unit of energy use in India in 2009 was 5.6 (constant 2005 purchasing power parity [PPP] $/kgoe). The GDP per unit of energy use during the same period was 3.6 (constant 2005 PPP $/kgoe) in low-income countries, 4.5 (constant 2005 PPP $/kgoe) in middle-income countries, and 7.6 (constant 2005 PPP $/kgoe) in high-income countries.

1.6.2. Economic indicators

a. The GDP at factor cost as per 2004/05 prices was `71 574 120 million (quarterly estimates for 2011/12).

b. The annual growth rate of GDP (advanced estimates for 2011/12) was 6.4%.

c. The per capita annual income at factor cost (current year prices for 2011/12) was Rs. 60 972.

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12 Indian energy sector: an overview, TERI Energy Data Directory and Yearbook 2012/13
d. Sectorial share of GDP was 14.4% for agriculture and allied activities, 27.9% for industry, and 57.7% for the services sector in 2010/11 (RBI 2012).

1.6.3. Social indicators

a. The population of India was 1.22 billion as of March 2012.

b. The decadal rate of growth of population was 17.64% for 2001–11 and the population density was 372 persons per km² in 2011.

c. The urban population of the country was 377.1 million in 2011.

d. About 69% of the population of the country lived in rural areas in 2011.

e. Of the total population of India, 33.7% people do not have access to electricity.

f. The net energy imports accounted for 30% of the total energy use in India in 2009/10 (TERI 2012).

The energy sector in India is unique both in terms of its organization as well as complexity, which results from the fact that India is a rapidly growing economy with huge disparity in incomes and lifestyles. Some salient features of the energy demand and supply sectors in India are as follows.

1.6.4. Energy demand

a. The Indian energy sector is complex due to a wide variation in lifestyle and use of different forms of energy by various sections of society. About 68% of India’s population still lives in rural areas and depends largely on noncommercial sources of energy such as fuel wood, biomass, and agricultural residue for their energy requirements for lighting and cooking. According to the 66th round of
Consumer Expenditure Survey in 2009/10, 76% of households in rural areas still use firewood as the primary cooking fuel and 33.54% of rural households used kerosene as a primary lighting fuel (MoSPI 2011). While an accurate estimate of non-commercial energy is not reported, by one estimate of the Ministry of New and Renewable Energy (MNRE), the availability of agricultural residue in India is about 539 million tonnes (MT). Therefore, the total energy consumption in India, including biomass, would be much higher than that indicated by the consumption figure of only commercial fuels.

b. Energy consumption has been increasing steadily in India to meet the requirements of economic growth and different development objectives. Table 1.1 shows the final commercial energy consumption in different sectors in India over the years.

Table No. 1.1- Final commercial energy consumption (in MTOE) in India by sector

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>1.6 (2.3%)</td>
<td>2.4 (2.6%)</td>
<td>4.9 (3.9%)</td>
<td>8.4 (5.3%)</td>
<td>15.2 (7.9%)</td>
<td>15.1 (6.9%)</td>
<td>23.14 (7.32%)</td>
</tr>
<tr>
<td>Industry</td>
<td>36.9 (53.7%)</td>
<td>49.2 (53.0%)</td>
<td>62.9 (50.4%)</td>
<td>77.5 (48.6%)</td>
<td>77.4 (40.4%)</td>
<td>96.2 (44.4%)</td>
<td>137.98 (43.62%)</td>
</tr>
<tr>
<td>Transport</td>
<td>17.4 (25.3%)</td>
<td>21.7 (23.4%)</td>
<td>28 (22.4%)</td>
<td>37.2 (23.4%)</td>
<td>33.5 (17.5%)</td>
<td>36.5 (16.8%)</td>
<td>55.34 (17.5%)</td>
</tr>
<tr>
<td>Residential and commercial</td>
<td>5.6 (8.1%)</td>
<td>8.9 (9.6%)</td>
<td>12.6 (10.1%)</td>
<td>15.3 (9.6%)</td>
<td>24.1 (12.6%)</td>
<td>32.6 (15.1%)</td>
<td>43.43 (13.73%)</td>
</tr>
<tr>
<td>Other energy uses</td>
<td>1.9 (2.8%)</td>
<td>2.7 (2.9%)</td>
<td>3.9 (3.1%)</td>
<td>6.8 (4.3%)</td>
<td>13.4 (7.0%)</td>
<td>18.7 (8.6%)</td>
<td>30.25 (9.56%)</td>
</tr>
<tr>
<td>Non-energy uses</td>
<td>5.3 (7.7%)</td>
<td>7.9 (8.5%)</td>
<td>12.6 (10.9%)</td>
<td>14.1 (8.8%)</td>
<td>28 (14.6%)</td>
<td>17.5 (8.1%)</td>
<td>26.15 (8.27%)</td>
</tr>
<tr>
<td>Total</td>
<td>68.7 (100%)</td>
<td>92.8 (100%)</td>
<td>124.9 (100%)</td>
<td>159.3 (100%)</td>
<td>191.6 (100%)</td>
<td>216.6 (100%)</td>
<td>316.29 (100%)</td>
</tr>
</tbody>
</table>
c. Retail energy prices in India are subsidized to support low-income households. End use energy prices in India are lower than international prices, but in purchasing power parity terms, prices seem much higher. The high subsidies have resulted in distorted allocation of energy and financial resources, and high under recoveries have burdened domestic companies. The 13th Finance Commission recommended that energy prices in India be brought in line with international energy prices. The Report of the Expert Group on a Viable and Sustainable System of Pricing of Petroleum Products, commissioned by the Government of India, recommended strategies for rationalization and phasing out of inefficient fossil fuel subsidies. In June 2010, the price of petrol was deregulated, and between May 2011 and August 2012, the price of petrol increased by almost 8% because of depreciation of the rupee and rising prices of imported crude oil. The price of diesel, which is partially deregulated, was also increased by `5/L, while that of kerosene and domestic liquefied petroleum gas (LPG) was also revised upwards as of October 2012. In a recent announcement, the government also restricted the supply of subsidized LPG for domestic cooking to six cylinders per household in a year.

d. Various demand-side management and energy efficiency improvement measures are being undertaken in various sectors in India. These include the Perform, Achieve, and Trade mechanism (which aims to promote the cost effectiveness of energy efficiency improvements in energy-intensive large industries), a National Standards and Labeling Programme for various appliances and buildings, and the Bachat Lamp Yojana for replacement of incandescent lamp.

1.6.5. Energy supply

a. The commercial energy supply in India is largely dependent on fossil fuels. Coal, oil and natural gas oil accounted for 91.74% of the total primary commercial energy supply in 2011. As on 31 March 2010, India has an estimated renewable power potential of 90 313 MW, but a large part of this potential
remains untapped and renewable energy accounts for only 1.65% of the total primary energy supply. Large hydropower accounts for 5.331% of the total primary energy supply (BP 2012).

b. Resource augmentation and growth in domestic energy supply have not kept pace with the increasing demand for energy. There are acute shortages of electricity, inadequate supply of good quality coal, and gas shortages. In 2011/12, the peak and total deficits of electricity were 9.8% and 8.5%, respectively, an improvement from 2010/11 where the corresponding deficits were 10.2% and 8.5%, respectively.

c. India’s energy sector is dominated by the public sector and state-operated companies, although the number of private companies is slowly increasing. For instance in 2009/10, public sector companies accounted for 91% of the total coal production in the country with the Coal India Ltd (CIL) alone accounting for 81% of the production. The Oil and Natural Gas Corporation Ltd (ONGC) and Oil India Ltd (OIL) are the dominant players in the upstream oil sector, and the Indian Oil Corporation Ltd is the largest player downstream.

d. The New Exploration and Licensing Policy (NELP) was formulated in 1997/98 to provide a level playing field to public and private sectors by allocating acreages based on competitive bidding rather than nomination. Recent rounds of NELP have seen participation from some Private sector players. Until 2006, pipeline gas transport was wholly public owned by the Gas Authority of India Ltd. However, now more private participation may be forthcoming. A Group of Ministers (GoM), headed by the Finance Minister, has been constituted to consider reintroduction of a bill to amend the Coal Mines (Nationalization) Act, 1973, which currently allows only public sector undertakings (PSUs) to undertake mining besides permitting mining besides permitting private firms to extract coal for captive use.
1.7. POTENTIAL FOR ENERGY CONSERVATION

a. India’s energy intensity per unit of GDP is higher compared to Japan, US and Asia by 3.7, 1.55 and 1.47 times respectively. This indicates inefficient use of energy but also substantial scope for energy saving.

b. One unit of energy saved at the consumer end avoids nearly 2.5 to 3 times of capacity augmentation due to auxiliary consumption and transmission and distribution losses.

c. The conservative estimate of potential of energy saving in India is creating nearly 25000 MW of new capacity.

1.7.1. Sector wise Potential for Energy Conservation

There is huge potential for energy conservation in India. The below Figure No.1.2 shows the sector wise potential for Energy Conservation:

**Figure No.1.2: Potential for Energy Conservation – Sector-wise**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Potential %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>Up to 25</td>
</tr>
<tr>
<td>Transport</td>
<td>Up to 20</td>
</tr>
<tr>
<td>Agricultural</td>
<td>Up to 30</td>
</tr>
<tr>
<td>Domestic and commercial</td>
<td>Up to 20</td>
</tr>
<tr>
<td>Economy as a whole</td>
<td>Up to 23</td>
</tr>
</tbody>
</table>

1.8. GOVERNMENT INITIATIVES FOR ENERGY CONSERVATION

Considering the vast potential of energy savings and benefits of energy efficiency, the Government of India enacted the Energy Conservation Act, 2001 (52 of 2001). The Act provides for the legal framework, institutional arrangement and a regulatory mechanism at the Central and State level to embark upon energy efficiency drive in the country.
Five major provisions of EC Act relate to Designated Consumers, Standard and Labelling of Appliances, Energy Conservation Building Codes, Creation of Institutional Set up (BEE- Bureau of Energy Efficiency) and Establishment of Energy Conservation Fund.

The Energy Conservation Act became effective from 1st March, 2002 and Bureau of Energy Efficiency (BEE) operationalized from 1st March, 2002. Energy efficiency institutional practices and programs in India are now mainly being guided through various voluntary and mandatory provisions of the Energy Conservation Act. The EC Act was amended in 2010 and the main amendments of the Act are given below:

1.8.1. The Energy Conservation (Amendment) Act, 2010- Main Amendments

a. The Central Government may issue the energy savings certificate to the designated consumer whose energy consumption is less than the prescribed norms and standards in accordance with the procedure as may be prescribed.

b. The designated consumer whose energy consumption is more than the prescribed norms and standards shall be entitled to purchase the energy savings certificate to comply with the prescribed norms and standards.

c. The Central Government may, in consultation with the Bureau, prescribe the value of per metric ton of oil equivalent of energy consumed.

d. Commercial buildings which are having a connected load of 100 kW or contract demand of 120 kVA and above come under the purview of ECBC under EC Act.

1.8.2. Energy Efficiency Measures

a. Standards and Labeling Programme

Standards and labeling (S&L) program has been identified as one of the key activities for energy efficiency improvements. A key objective of this scheme is to provide the consumer an informed choice about the energy saving and thereby the cost saving potential of the relevant marketed product. The scheme was launched by the Hon'ble Minister of Power on 18th May 2006 and is currently
invoked for 12 equipments/appliances, i.e. ACs, Tube lights, Frost Free Refrigerators, Distribution Transformers, Induction Motors, Direct Cool Refrigerator, Geysers, Ceiling fans, Colour TVs, Agricultural pump sets, LPG stoves and Washing machine, of which the first 4 have been notified under mandatory labelling from 7th January, 2010. The STAR rating ranges from 1 to 5 in the increasing order of energy efficiency.

b. **Demand Side Management**

The Demand Side Management (DSM) and increased electricity end use efficiency can together mitigate power shortages to a certain extent and drastically reduce capital needs for power capacity expansion. The Bureau will be assisting 5 electric utilities to set up DSM Cell and will also assist in capacity building of DSM Cell staff. The preparation of investment grade feasibility reports on agricultural DSM, municipal water pumping and domestic lighting in each of the 5 states will also be undertaken by the Bureau under DSM Programme.

c. **Agriculture Demand Side Management (Ag DSM)**

Bureau of energy efficiency (BEE) initiated Agriculture Demand Side Management (Ag DSM) scheme in the XI five year plan period as a key strategy to address the existing inefficiencies in the end use segments of agriculture sector. The objective of the programme was to create appropriate framework for market based interventions in agricultural pumping sector by facilitating conducive policy environment. Pump set efficiency up gradation through PPP mode was one the key aspects of this scheme. The replacement of existing inefficient pump sets with energy efficient (BEE star labelled) pump sets would unlock the market for large scale investments in this area. A recent study estimates a total saving potential of 27.79 billion Kwh in Indian agricultural pumping sector. This accounts for 37% of the overall energy saving potential and about 40% of the overall energy deficit reported during 2007-08.
d. Municipal demand side management

Municipal DSM programme is first of its kind and carried out across the country for 171 Urban Local bodies (ULBs). This programme was divided into 5 different phases. Phase 1 covers 24 ULBs, phase 2 covers 55 ULBs, Phase 3 covers 33 ULBs, Phase 4 covers 31 ULBs and remaining ULBs will be covered in the 5th phase. The basic objective of the project is to improve the overall energy efficiency of the ULBs, which could lead to substantial savings in the electricity consumption, thereby resulting in cost reduction/savings for the ULBs.

e. Energy Conservation Building Code (ECBC)

The Energy Conservation Building Code (ECBC) was launched by the Government of India on 27th May, 2007. The ECBC sets minimum energy standards for new commercial buildings having a connected load of 100kW or contract demand of 120kVA in terms of Energy Conservation (Amendment) Act, 2010.

Harmonization of ECBC with National Building Code (NBC) is also under progress by including a chapter on "Approach to Sustainability" in NBC-2005. BEE has developed ECO-nirman conformance check tool with an objective of helping architects and design professionals to assess the conformance of their designs with code requirements.

f. Bachat Lamp Yojana (BLY)

Bachat Lamp Yojana (BLY) promotes energy efficient and high quality CFLs as a replacement for incandescent bulbs in households at the rate of an incandescent bulb, i.e. Rs 15. This would remove barrier of high CFL price (which is currently Rs 80 - Rs 100 per CFL) which is constraining its penetration into households. It targets replacement of about 400 million incandescent bulbs in use in the country, leading to a possible reduction of 4000 MW of electricity demand, and a reduction of about 24 million tonnes of CO2 emissions every year. Kerala State has distributed the CFLs in the entire state.
Karnataka State has also launched the scheme and CFL distribution has started. BLY is at different stages of implementation in many other states like Punjab, Haryana, Andhra Pradesh, Orissa, Chhattisgarh, Madhya Pradesh, Uttar Pradesh, Uttarakhand, Rajasthan, Goa, West Bengal, Tamilnadu and Delhi.

g. Strengthening Institutional Capacity of State Designated Agencies (SDAs)

State Designated Agencies (SDAs) are statutory bodies set up by states to implement energy conservation measures at state level. The main emphasis of the scheme is to build capacity of the SDAs to enable them to discharge regulatory, facilitative and enforcement functions under the EC Act 2001.

The Ministry of Power had approved the scheme to provide financial support to the SDAs for strengthening their institutional capacity. Under the SDA scheme financial support was provided to the SDAs to carry out the following activities:

i. Creation of IT infrastructure

ii. Creation of database for Energy Managers / Energy Auditors and Designated Consumers and other stakeholders.

iii. Organizing workshops / training programmes

iv. Creating awareness through electronic media / print media


vi. Implementation of Energy Efficiency Demonstration Projects in the area of energy efficient street lighting, revamping of drinking water pumping system and energy efficiency in SMEs clusters

vii. To convert the existing incandescent bulbs (ILBs) in the households and the street lights of one village with LEDs.

h. State Energy Conservation Fund (SECF)

SECF is a statutory requirement under section 16 of the Energy Conservation Act 2001 and is one of the key elements of the ECAP. The scheme is for support
of Rs. 70 Crores as contribution by BEE to SECF to invest in Energy Efficiency projects. The effort will be to create a pool of financially sustainable activities for SDAs (like training programmes, fee for services, etc) which can augment the fund.

i. Energy Efficiency in Small and Medium Enterprises (SMEs) and Designated Consumers

Energy use and technology gap study has been completed in 20 SMEs cluster and is in progress in other 5 clusters. Cluster specific manual on energy conservation opportunities have been prepared in 20 clusters and information dissemination workshop for various stakeholders have been completed in 34 clusters. Preparation of Detailed Project Report on energy efficient technologies is under progress.

j. Professional certification and Accreditation

As per the Energy Conservation Act, it is mandatory for all the designated energy consumers to get energy audit conducted by an Accredited Energy Auditor and to designate or appoint an Energy Manager. The Government of India has specified the passing of the National level certification examination as the qualification for a Certified Energy Manager & Certified Energy Auditor. The Bureau has successfully conducted Ten National Certification Examinations since 2004. After 10th Examination, 8026 persons have been qualified as energy managers out of which 5731 have been qualified as energy auditors.

k. Manual and Codes

Energy audits have been conducted in past with little or no standard test procedures and inadequate instrumentation. Manuals and codes on 7 Technologies (Equipment) Lighting Systems; Dryers; Cogeneration Plants; Electric Motors; Electric Transformers; Fluid piping systems (network),
insulation and Air Conditioners/Chillers (HVAC) have been prepared. The manuals and code would help in standardizing the process of energy audit to support energy manager and energy auditors.

l. School Education Programme
Considering the need to make the next generation more aware regarding efficient use of energy resources, it is necessary to introduce children during their school education. In this regard, promotion of energy efficiency in schools is being promoted through the BEACON project which is now in its third phase. The main methodology being adopted by this project is to train a minimum of 3 teachers as Master Trainers from 30 schools across several towns and cities in 22 states. These master trainers will assume the role of further training other teachers and students to ensure sustainability and continuity of the project.

m. Indo-German Energy Efficiency Project (Phase-II)
The Phase-I of the Indo-German Energy Efficiency Project has been successfully completed by the Bureau of Energy Efficiency (BEE) in September 2009. Activities in the Phase-II of the Project have already begun and the project would be supporting the thrust areas of the Bureau as mentioned above.

n. Energy Conservation Awards
The Energy Conservation Awards recognize innovation and achievements in energy conservation by the Industries, buildings, zonal railways, state designated agencies, aviation; manufacturers of BEE star labelled appliances and municipalities and raise awareness that energy conservation plays a big part in India's response to reducing global warming through energy savings.

The awards scheme has been in operation since 1991. The participating units of 2010 awards have collectively invested Rs.5457 crores in energy conservation.
measures, and achieved a monetary savings of Rs. 2138 crores every year, implying a payback period of 31 months only, once again proving the fact that energy conservation is a least cost option. The participating units have also saved electrical energy of 2422 Million kWh of electrical energy, which is equivalent to the energy generated from a 357 MW thermal power station.

The following Figure No. 1.6 shows electrical energy savings in terms of equivalent avoided capacity in (Mega-Watts) and Figure No. 1.7 shows Encouraging response from Indian industry in the national energy conservation award scheme (1999-2010)

**Figure No. 1.6 Electrical energy savings in terms of equivalent avoided capacity in (Mega-Watts)**

![Figure No. 1.6 Electrical energy savings in terms of equivalent avoided capacity in (Mega-Watts)](image1)

**Figure No. 1.7 Encouraging response from Indian industry in the national energy conservation award scheme (1999-2010)**

![Figure No. 1.7 Encouraging response from Indian industry in the national energy conservation award scheme (1999-2010)](image2)
It is hoped that National energy Conservation Award Scheme would help in motivating the other energy consumers in joining and promotion of a nationwide energy conservation movement.

o. **Painting Competition on Energy Conservation, 2010**

Ministry of Power has undertaken National Campaign on Energy Conservation 2010. Under this campaign, a painting competition on energy conservation at School, State and National level are conducted. The painting competition is first conducted at the School level and two best paintings from the participating school are included in the concerned State/UT level Competition. First two winners from each State and UTs are invited to participate at the national level competition. This year, 47155 Schools and 15.63 lakhs students of 4th, 5th and 6th standards of the 35 States and Union Territories participated in the School Level Painting Competition, which was quite encouraging. This competition is aimed at motivating the children towards energy conservation and offers them a chance to explore their creativity. The expressive paintings of the children reflected their interest in the energy conservation activities and their concern about climate change.


The National Mission for Enhanced Energy Efficiency is one of the eight missions under the National Action Plan on Climate Change. The objective of the Mission is to achieve growth with ecological sustainability by devising cost effective strategies for end-use demand side management. The Ministry of Power (MoP) and Bureau of Energy Efficiency (BEE) have been entrusted with the task of preparing the implementation plan for the National Mission for Enhanced Energy Efficiency (NMEEE) and to upscale the efforts to create and sustain market for energy efficiency to unlock investment of around Rs. 74,000 Crores. The Mission, by 2014-15, is likely to achieve about 23 million tons oil-equivalent of fuel savings- in coal, gas, and petroleum products, along with an
expected avoided capacity addition of over 19,000 MW. The carbon dioxide emission reduction is estimated to be 98.55 million tons annually.

NMEEE will usher in the following four initiatives, in addition to the policies and programmes for energy efficiency being implemented by BEE. These initiatives are as follows:

i. **Perform, Achieve and Trade (PAT)**, which is a market, based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded.

   Targets for improvements in energy efficiency will be set under Section 14 of the Energy Conservation Act, 2001 in a manner that reflects fuel usage and the economic effort involved. The Government, in March 2007, notified units in nine sectors, namely aluminium, cement, chlor-alkali, fertilizers, iron and steel, pulp and paper, railways, textiles and thermal power plants, as Designated Consumers (DCs).

ii. **Market Transformation for Energy Efficiency (MTEE)** to accelerate the shift to energy efficient appliances in designated sectors through innovative measures to make the products more affordable with focus on leveraging international financial instruments, including Clean Development Mechanism (CDM) to make energy efficient appliances affordable and increase their levels of penetration.

iii. **Energy Efficiency Financing Platform (EEFP)**, to help stimulate necessary funding for Energy Service Company (ESCO) based delivery mechanisms for energy efficiency. The costs will be recovered from the energy savings, which will also reduce the subsidy bill of the state government. The scheme has the potential to be replicated across the country.
In an effort to provide EEFP, MoUs with M/s. PTC India Ltd, M/s. SIDBI and HSBC Bank have been signed by BEE. PTC India Ltd. has commenced financing of several building energy efficiency projects in Rashtrapati Bhavan Estate, ESIC Hospitals at Rohini and East Delhi, AIIMS, Safdarjung Hospital. SIDBI has taken up project preparation of energy efficiency projects in 25 SME clusters which will then be offered financing.

iv. **Framework for Energy Efficient Economic Development (FEEED)**, seeks to develop fiscal instruments to promote energy efficiency including innovative fiscal instruments and policy measures like the Partial Risk Guarantee Fund (PRGF) and Venture Capital Fund for Energy Efficiency (VCFEE), Public Procurement of energy efficient goods and services, Utility based Demand Side Management (DSM), etc.

Efforts of the government to create a market for energy efficiency need to be supplemented with appropriate fiscal instruments.

q. **Partial Risk Guarantee Fund (PRGF)**

A PRGF is a risk sharing mechanism lowering the risk to the lender by substituting part of the risk of the borrower by granting guarantees ensuring repayment of part of the loan upon a default event. The guarantee can seek to directly support financing of energy-efficiency projects by:

Addressing credit risk and barriers to structuring the transactions involved in financing energy-efficiency projects and

Engaging commercial financial institutions and building their capacity to finance energy-efficiency projects on a commercially sustainable basis.

r. **Venture Capital Fund for Energy Efficiency (VCFEE)**

VCFEE as envisaged by the Government of India under the National Mission for Enhanced Energy Efficiency can go long way in addressing these barriers
and kick starting some of the long awaited energy efficiency projects in the

country.

Under this initiative, framework development for financial institutions to
promote energy efficiency is in process. Document on institutional framework
and RfP for hiring fund manager for Partial Risk Guarantee Fund (PRGF) and
Venture Capital Fund (VCF) are being finalized.

Study on fiscal and monetary policy of energy efficiency projects have been
awarded to National Institute of Public Finance and Policy (NIPFP).

1.9. NATIONAL INSTITUTIONS PROMOTING ENERGY CONSERVATION

India has a long history of promoting energy efficiency through various national level
institutions, which include BEE, PCRA, IREDA, NPC, NCB, TERI, CII and FICCI. After the enactment of Energy Conservation Act -2001, these institutions have become
more active. Though each institution has a different role and approach, they all are
working for a common cause of energy conservation. "Industrial Chronicle" presents a
report on each institution's energy efficiency promoting efforts.

a. **Bureau of Energy Efficiency (BEE)**

   After the notification of Energy Conservation Act in the Gazette of India in
   October 2001, the Ministry of Power, Govt. of India, established the Bureau of
   Energy Efficiency (BEE) in March 2002 with the mandate to implement the
   Energy Conservation Act properly throughout the country. BEE's mission is to
   institutionalize energy efficiency services, enable delivery mechanisms in the
country and provide leadership to the key players involved in the energy
   conservation movement. Its primary goal is to reduce the energy intensity in the
economy. BEE is the first energy efficiency promoting organization, which has
been given wide legal powers to enforce the energy conservation related
provisions of the Act and also to take punitive actions against the defaulters.
Penalty for each offence under the Act would be in monetary terms and the same
is fixed at Rs. 10,000 for each offence and Rs. 1000 for each day for continued
non-compliance. However, during the initial phase of 5 years being promotional and creating infrastructure for implementation of the Act, no penalties would be effective during this phase.

b. Petroleum Conservation Research Association (PCRA)
Responding to the oil crisis of early seventies, the government had created Petroleum Conservation Research Association (PCRA) in 1978 to identify potential and to promote measures for accelerating conservation of petroleum products in various sectors of economy. Currently under the Ministry of Petroleum & Gas, PCRA is one of the key organizations working towards energy conservation with a special focus on energy efficiency in industrial units. It sponsors R&D activities for the development of fuel-efficient equipment/devices and organizes multi-media campaigns for creating mass awareness for the conservation of petroleum products. It has also been promoting energy audits and presenting awards to State road transport corporations, industrial units, energy auditors and ESCOs in recognition of their energy saving achievements. Table No 1.3: PCRA's achievements in saving of petroleum products. It also organizes a training Programme on "Energy Management and Conservation Strategies" in association with Administrative Staff College of India (ASCI) at Hyderabad.

<table>
<thead>
<tr>
<th>Year</th>
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<tr>
<td>1992-93</td>
<td>332</td>
<td>2000-01</td>
<td>1782</td>
</tr>
</tbody>
</table>
c. **Indian Renewable Energy Development Agency (IREDA)**

IREDA was promoted by the government in 1987, mainly for promotion of renewable energy sources like wind, hydro, solar, biomass, waste to energy etc. Later it diversified into energy efficiency and conservation. Today IREDA extends financial assistance for renewable energy, energy efficiency and conservation projects with the motto: "energy forever". IREDA's financial assistance is available to industries for their energy saving projects up to 70% to 75% of the total project cost at a concessional rate of interest on a long term basis. Till March 2003, IREDA approved an aggregate 1711 projects with financial commitment of about Rs. 6675 crores and disbursed Rs. 3640 crores. The projects financed by it created 2472 MW power generation capacity.

d. **National Productivity Council (NPC)**

Founded in 1958 by the Government of India, the National Productivity Council (NPC) is a national level autonomous, tri-partite, non-profit organization with equal representation from the government, employers and workers' organizations, apart from technical and professional institutions. Besides its headquarters at New Delhi, NPC operates through 12 offices in India with 250 full-time highly qualified and experienced specialists representing various disciplines. Its services include consultancy, training and research in the area of productivity and energy.

NPC has a training wing known as Dr. Ambedkar Institute of Productivity (AIP) at Chennai, which conducts a two years full time PG programmes in energy management, environment management, industrial engineering etc. Two years ago, Bureau of Energy Efficiency (BEE) had entrusted it with the responsibility of conducting national level certification examinations for energy auditors and energy managers.

e. **National Council for Cement & Building Materials (NCB)**

Established in 1962, NCB has been actively engaged in carrying out energy audit studies, monitoring of energy performance of cement plants, R&D on
energy conservation and rational utilization of energy, heat and gas balance studies, identification of leakages in kiln-preheater and other gas/air circuits, identification of potentials for energy saving, on-site study of process parameters, target-setting and monitoring, waste heat recovery for cogeneration of power, creating awareness and motivation through National Awards for Energy Efficiency in Indian Cement Industry, manpower training in energy management and auditing, bringing out publications/newsletter related to energy conservation aspects.

During the past two decades, it has carried out about 145 energy audit studies in cement plants. Jointly with the Bureau of Industrial Costs and Prices (BICP), NCB had conducted an energy use survey of Indian industry in 1983-84 and again ten years later.

f. The Energy Research Institute (TERI)

The Energy Research Institute (TERI), formerly known as Tata Energy Research Institute, was established in 1974. TERI has been actively working in close association with the Indian industry for developing solutions for the challenges posed by the growing demand for energy. It has conducted energy audits in more than 200 industrial organizations.

With a staff strength of over 600, today TERI is providing environment-friendly solutions to rural energy problems, helping shape the development of the Indian oil and gas sector, tackling global climate change issues across many continents, enhancing forest conservation efforts among local communities, advancing solutions to growing urban transport and air pollution problems, and promoting energy efficiency in the Indian industry. It conducts various training programmes and also publishes books.

g. Confederation of Indian Industry (CII)

Founded over 110 years ago, it is India's premier business association with a direct membership of over 5300 companies from the private as well as public
sectors. It accords energy sector A+ priority area. To provide focus and direction to energy related issues, its energy division undertakes activities in power, hydrocarbons, coal, renewables and energy efficiency. CII's Energy Management Cell has already conducted nearly 450 detailed energy audits in units representing various industrial sectors. The audited units have reported a recurring annual savings of over Rs. 110 crores. PCRA has repeatedly honoured this Cell with its "Best Energy Auditor Award".

h. Federation of Indian Chambers of Commerce and Industry (FICCI)
Set up in 1927, on the advice of Mahatma Gandhi, the Federation of Indian Chambers of Commerce and Industry (FICCI) is the rallying point for free enterprises in India. It promotes energy efficiency activities by conducting energy audits, energy conservation seminars, training programmes and workshops. It has qualified experts for energy audits and experienced panel of faculties for training. FICCI is also an accredited energy auditor of Petroleum Conservation Research Association (PCRA).

1.9.1. Leading State Level Organizations Promoting Energy Efficiency

a. Maharashtra Energy Development Agency (MEDA)
Among the State level organizations promoting energy conservation in the country, the Maharashtra Energy Development Agency (MEDA) stands No.1. Its major energy efficiency programmes include: save energy, energy conservation awards, conference on energy efficiency, and intensive training to participants appearing for BEE examination. MEDA has facilitated energy audits in 379 industrial units, which have saved energy worth Rs. 27.61 crores. It also maintains a list of empanelled energy auditors and ESCOs. Under EC Act, MEDA has been designated as nodal agency in Maharashtra.
b. Energy Management Centre (EMC), Kerala

Established at Thimvananthapuram (Trivandrum) in February 1996, Energy Management Centre (EMC) is an autonomous organization under the Department of Power, Govt. of Kerala. EMC promotes energy conservation in all sectors of the economy through scientific and technological research, education and training as well as professional consultancy and advice.

c. Madhya Pradesh Urja Vikas Nigam (MPUVN)

Madhya Pradesh Urja Vikas Nigam Ltd. is a notified 'designated agency' in Madhya Pradesh. MPUVN has completed over 450 energy audits in industrial, domestic, agricultural and commercial building sectors, savings energy worth Rs.35 crores per year. It has initiated capacity building programmes, persuaded the State government to make energy audit compulsory and set a target to save energy up to 30%.

d. Energy Conservation Mission (ECM)

The Institution of Engineers (India) having recognized the need for enhancing awareness in energy conservation measures in various sectors, authorized AP State Centre to constitute "Energy Conservation Mission" (ECM). The main objective of ECM is to create public awareness through dissemination of information on energy conservation.

1.10. NEED FOR ENERGY CONSERVATION IN MAHARASTRA

At present, there is a gap of 4000 MW between demand and supply of the electricity in the State of Maharashtra. To install 4000 MW capacity, the requirement of capital is of the order of approximately Rs.16, 000crore. Gestation period for setting up new power projects is of the order of approximately 4 years to 5 years. Hence, the energy conservation measures provide cheapest way to bridge the demand and supply gap with minimum capital investment. It also improves the plant load factor of generating stations which helps to reduce the cost of electricity.
Maharashtra is one of India’s leading industrial states. It has about 29,562 industries of which around 10,000 HT industries are established within it. Also, Maharashtra is the largest producer of electricity in the country. Hence, there is a huge potential for energy saving in all sectors which is near about 3,000 MW.

1.11. NEED FOR THE PRESENT STUDY

Indian industry uses energy more intensively than is the norm in industrialized countries. While selected modern Indian units often display very high efficiency that approaches world best practice levels, the average intensity lags world best levels. Indian industry has undergone a transformation since 1991, the year the economy was opened to foreign investment and competition. Energy per unit of valued added in the industrial sector has declined since then. However, there still remains considerable scope for continued improvement of energy efficiency in Indian industry, and for learning from both worldwide and Indian best practices. (Jayant Sathare, Lynn Price, Stephane de la Rue du Can, David Fridley, 2005)

a. With rising fuel costs and the opening of electricity and gas markets to alternate suppliers and climate change, the need to monitor and reduce energy consumption is receiving greater attention than ever before. Industry is the largest consumer of primary commercial energy in India. Adoption of Energy Efficiency Technologies in industries especially in utilities will definitely reduce overall energy consumption. A study required to describe the status of adoption of energy efficient technologies.

b. Global warming has become a global issue and the main reason is emissions from Green House gases. Although carbon emissions in India remain low in per capita terms, total emissions are growing and will continue to grow with industrialization and increases in electricity supply. Improvements in energy efficiency (i.e., reductions in energy per unit of output) are often suggested as a means of reducing carbon emissions. In many cases, improvements in energy efficiency will pay for themselves through reductions in fuel costs and would, therefore, be desirable even
if climate change were not a concern. A study is required to explore the possibilities of energy savings to reduce energy consumption.

c. The usage of energy resources in industry leads to environmental damages by polluting the atmosphere. Few of examples of air pollution are sulphur dioxide (SO2), nitrous oxide (NOX) and carbon monoxide (CO) emissions from boilers and furnaces, chloro-fluro carbons (CFC) emissions from refrigerants use, untreated Effluents etc. In Pune, surprisingly, SO2 levels have increased substantially from 13.85 µg/m3, to 49.15 µg/m3. Pune is well developed industrially and is one of the badly polluted city in the state. Variety of air pollutants in utilities system have known or suspected harmful effects on human health and the environment. A study is required to explore the possibilities of reducing energy consumption, thereby reducing pollution and its harmful environmental effects.

d. Some companies improve their energy efficiency and others don’t. This is because these companies are faced with a range of financial, cultural, technical and external barriers that affect their ability to adopt energy efficiency measures. The question is, what are they and how can we overcome the barriers?

There is a large international literature that examines barriers to Energy Efficiency. There are virtually no such studies for India especially in industries. Such studies would provide useful information about the barriers to Energy Efficiency and corrective measures can be taken to improve energy efficiency.

e. Periodic performance assessment of utility equipment evaluates the actual performance of a facility's systems and equipment against their designed performance level. The difference between these two is potential for saving. Unfortunately; there are no standard procedures available and followed by most of the industries to measure the performance of major utility equipment like Air Compressor, Chiller, Boiler, Pumps and Electrical systems against their design parameters. A study is required to understand whether the performance assessment of utility equipment is being carried out in industries at periodic intervals.
f. Utility cost estimates are often complicated because they depend on both inflation and energy costs. Unlike capital, labour, and other expenses, utility prices do not correlate simply with conventional inflationary indexes, because basic energy costs vary erratically, independent of capital and labour.

Except Electrical utility, awareness about the unit cost of other utilities like Compressed Air, Chilled water, Steam, treated water etc. is very low. Utilities cost calculation is not being done with standard procedure in majority of industries. Specific utility energy prices are undervalued and energy wastages are not taken seriously.

g. Training on energy management is very important to create awareness among the people about effective energy management and to understand technical and managerial aspects of it. Awareness among the employees about utilities pricing and its conservation practices in industries is considerably very low as more importance is given to manufacturing activities. However, some energy intensive industries realized importance and benefits of Energy Conservation and they have taken some initiatives for creating awareness about the energy conservation through various training programs but very less in numbers. One of the objective of the present study is to understand the status of training programs on energy management and identify the training needs of employees on energy management.

1.12. SCOPE OF THE RESEARCH STUDY

Considering nature of the problem which is very vast and multi-dimensional, for academic purpose, scope of the study was restricted to energy management at plant level utilities to reduce energy consumption. Geographical scope was restricted to automobile industries manufacturing passenger cars in Pune because of the wide spread number of industries.
According to United Nations, Passenger car is a Road motor vehicle, other than a motor cycle, intended for the carriage of passengers and designed to seat no more than nine persons (including the driver).

1.13. STATEMENT OF THE RESEARCH PROBLEM

Energy conservation is one of the critical issues facing society today. Our civilization runs on energy. However, energy resources are finite. Increasing demand is being made for diminishing supplies. The cost of energy is enormous, and the cost is rising. Utility bills account for much of the cost of housing, and they are a major cost of business. Industries spend crores of rupees for energy each year. This consumption brings a host of environmental dangers. As a result, energy conservation has become a universal concern. Increasing demand for power has led to considerable fossil fuels burning which has in turn had an adverse impact on environment. In this context, efficient use of energy and its conservation is of paramount importance. Industry is the largest consumer of primary commercial energy in India. Adoption of Energy Efficiency Technologies in industries especially in utilities will definitely reduce overall energy consumption. Global warming has become a global issue and the main reason is emissions from Green House gases. Although carbon emissions in India remain low in per capita terms, total emissions are growing and will continue to grow with industrialization and increases in electricity supply. Improvements in energy efficiency (i.e., reductions in energy per unit of output) are often suggested as a means of reducing carbon emissions. Some companies improve their energy efficiency and others don’t. This is because these companies are faced with a range of financial, cultural, technical and external barriers that affect their ability to adopt energy efficiency measures. Training on energy management is very important to create awareness among the people about effective energy management and to understand technical and managerial aspects of it. Awareness among the employees about utilities pricing and its conservation practices in industries is considerably very low as more importance is given to manufacturing activities.
Numerous studies conducted in the field of industrial energy efficiency shows that there are tremendous saving potential that can be achieved through the effective implementation of energy management in industries. A study by Caffal (1996) revealed that industrial energy management has the potential of saving about 40% of energy use in an industrial facility. So to understand energy conservation measures taken by the industries to elaborate possibilities of energy savings and to understand barriers to energy efficiency and training needs of employee with respect to energy management induced to study this research problem.

1.14. RESEARCH OBJECTIVES AND RESEARCH QUESTIONS

The primary aim of this project is to provide a comprehensive overview of the present energy management measures adapted in passenger cars manufacturing automobile industries in Pune to explore the possibilities of energy savings. To better explore the nature of energy management strategies in the study area, the project will also investigate the barriers for the implementation of energy efficient technologies in utilities. Specifically, this thesis aims to:

1. To study the Energy Management measures adopted by selected industries to explore the possibilities of Energy Savings.
2. To study the practice of Utilities cost calculation by selected Industries.
3. To study the co-ordination between utilities Generation and Demand for optimization of utilities.
4. To study the training needs of employees for energy management in utilities.
5. To study the barriers in adoption of Energy Efficient Technologies in selected industries.

In order to achieve the objectives of this thesis work, the under listed research questions will be addressed:

1. What are the energy conservation measures adopted by industries?
2. Whether utilities costing are practiced in industries and have they a standard procedure for it?
3. Whether there is a systematic co-ordination between utilities generation and demand for optimization of utilities.
4. What are the training needs of employees for successful energy management in utilities?
5. What barriers hinder the implementation of energy efficient technologies in industries?
6. Whether performance assessment of major utility equipment is done?
7. Whether training is provided on energy management? If yes, is it adequate?
8. Whether effective application of energy efficient technologies in utilities has taken place?

1.15. ENERGY SYSTEM OF UTILITIES IN INDUSTRIES

The industrial sector alone accounts for about 50% of the commercial energy. It uses both, the thermal and electrical energy in various equipment like boilers, compressors, furnaces, diesel generating engines, motors, pumps, refrigeration etc.

There are various energy systems/utility services which provides the required type of secondary energy such as compressed air, chilled water, steam/hot water etc. to the production facility in the manufacturing plant. Although various forms of energy such as coal, oil, electricity etc. enters the facility and does its work or heating, the outgoing energy is usually in the form of low temperature heat. All energy/utility systems can be classified into three areas like generation, distribution and utilization. A typical energy system of plant level utilities is as per the following:

a. Compressed air

Compressed air is used in almost all types of industries and accounts for a major share of electricity used in some of the plants. It is utilized for a variety of end uses such as pneumatic tools and equipment, instrumentation, conveying, etc. and is preferred in industries because of its convenience and safety. Normally, the compressed air factor is an overlooked area in most of the industries, though it is a costly source of power, about 7 to 10 times the cost of electricity. Given
this economics, better maintenance practices and elimination of wastage would help in improving the performance of compressed air systems. The following figure No. 1.8 shows typical Plant Energy Diagram.

Figure No 1.8: Plant Energy Diagram

![Plant Energy Diagram](image)

Most industrial facilities need some form of compressed air, whether for running a simple air tool or for more complicated tasks such as operation of pneumatic controls. A recent survey by the U.S. Department of Energy showed that for a typical industrial facility, approximately 10% of the electricity consumed is for generating compressed air. For some facilities, compressed air generation may account for 30% or more of the electricity consumed. Compressed air is an on-site generated utility. Very often the cost of generation is not known.

Compressed air is one of the most expensive sources of energy in a plant. The overall efficiency of a typical compressed air system can be as low as 10-15%. For example, to operate a 1 HP air motor at 100 psig, approximately 7-8 HP of electrical power is supplied to the air compressor.¹³

¹³Energy Tips, December 2000, Office of the industrial technologies, energy efficiency and renewable energy, U.S. Department of Energy
b. **Cooling towers**

Cooling tower and cooling water supply system is widely used in industries for cooling demand. A cooling tower is a specialized heat exchanger in which two fluids (air and water) are brought into direct contact with each other to effect the transfer of heat. In a spray filled towers, this is accomplished by spraying a flowing mass of water into a rain-like pattern, through which an upward moving mass flow of cool air is induced by the action of a fan. There are two basic types of cooling towers, direct (or open) and indirect (or closed).

c. **Electric motors**

The electric motors are used to provide motive power to equipment such as compressors, pumps, blowers, etc. It is important that the industrial users define their need accurately to enable proper selection of a motor for a particular application. Of the total electricity consumed in the industrial sector, electric motors account for approximately 70%.

The motors are classified under DC (direct current), AC (alternating current) synchronous, and AC induction (squirrel cage or wound rotor type) types. The AC induction is additionally distinguished as single or polyphase. Most of the power consumed by motors in the industry is accounted for by polyphase (three-phase) AC induction motors. Of the three-phase induction motors, the squirrel cage motor is most popularly used because of its relatively low capital and maintenance costs, and rugged design.

d. **Lighting**

A lumen is the measurement of light output from a lamp, often called a tube or a bulb. All lamps are rated in lumens. For example, a 100-W incandescent lamp produces about 1750 lumens. The distribution of light on a horizontal surface is called its illumination, which is measured in foot-candles or lux. A foot-candle of illumination is a lumen of light distributed over one-square-foot (0.09 m²) area. Another lighting term is efficacy, which is the ratio of light output from a
lamp to the electric power it consumes and is measured in LPW (lumens per watt).

Lighting uses can be divided into three categories: ambient, task, and accent. Ambient lighting provides security and safety, as well as general illumination for performing daily activities. The goal of task lighting is to provide enough illumination so that tasks can be completed accurately. The idea here is not to illuminate the entire area. Accent lighting illuminates walls to blend more closely with naturally bright areas like ceilings and windows.

e. Pump

Most of the industrial processes in and out of plants involve transportation of fluids and the pump is the only mechanical means available to facilitate this transportation. Work has to be done by a prime mover in order to enable the pump to discharge its functions, because the pump is incapable of transporting the fluid on its own. The prime mover can either be an electric motor, a diesel engine, or a steam/gas turbine. All prime movers consume energy, either in the form of electric power or precious petroleum products like diesel, oil or gas, to impart working capacity to the pump.

f. Refrigeration and Air-Conditioning

Refrigeration is the process of removing heat at a low temperature level and rejecting it at a relatively higher temperature level. Refrigeration is accomplished by various methods, such as the vapour compression system, absorption system, and steam jet refrigeration cycle. The most commonly used systems are the vapour compression and absorption systems. Further, even out of above two, the vapour compression system is more widely used.

The items required for the make-up of a complete refrigeration and air-conditioning system are refrigerating equipment, fans, pumps, cooling towers, filters, air-handling units, and ducting. Depending upon the process, all or some of the items mentioned may be required.
g. **Boilers**

Fuels such as furnace oil, coal are purchased and then converted into steam, hot water with steam boiler/ hot water generator. Boilers are used in various industrial units to convey heat for different process applications. Steam is commonly used as the heating medium mainly due to two reasons: one - it is generated from water which is usually available; and two - it is able to store a large quantity of heat at a temperature which can be conveniently used. Various types of fuels, namely; coal, oil, gas, biomass, etc. are used for steam generation in boilers depending on the availability of fuel and cost economics prevailing in the plant. Some of the boilers even use waste (generally low calorific value fuels) as fuel. For example, paper industries use black liquor generated within the plant as fuel.

Boilers can be categorized into different types depending on water/flue gas passage in the boiler, fuel usage, and pressure generation. The types of boilers vary with respect to the requirement of the plant. Whatever may be the type of boiler used, the motive of the industry should be to generate the required quantity and quality of steam at minimum possible costs. This can only be achieved by reducing the various avoidable heat losses occurring within the boiler system, thus improving the efficiency of the same.

h. **Diesel generating sets:**

Some plants generate their own electricity using DG sets or captive power plants. With the gap between the demand and supply of electric power widening, the role of diesel generating sets in the Indian industry cannot be overemphasized. Depending on the type of industry, its sitting, and the magnitude of the connected load, DG sets are employed in various modes like: the standby mode to meet a part or the full requirement of the plant in case of power failures; the peak-load mode to meet the requirement during peak demand, thereby reducing the maximum demand; the base-load mode, where a part or whole of the plant's requirement is met on a continuous basis; and the total energy mode, where it not only supplies the total power required but also
meets the heating and cooling requirements of the plant by utilizing the waste heat from the DG set exhaust in an integrated system.

1.16. ENERGY CONSERVATION MANAGEMENT

Every industry or commercial undertakings need a specific amount of energy to undertake the process and operations. It could be in the form of electrical energy, thermal energy or any other forms of energy use. During good old days, when energy was in surplus, no one cared about designing the system to minimize the energy use. In addition to this, designers used to take huge safety margins on one side and extra precaution on initial capital investment on the other, which also led to extra amount of energy consumption to undertake a specific task. However, the situation has changed now dramatically and survival becomes a question mark in front of most of the industries that were enjoying a very comfortable position earlier. Under such a scenario, competitive pricing strategy is the only option for survival. To cut price, the cost of production needs to be reduced. The energy cost is 5 to 25% or even more in Indian Industry.

Energy management is the philosophy of more efficient energy use, without compromising upon production levels, product quality, safety and environmental standards. However, as in other commercial and economic facet, the concept of energy management is dominated by the cost efficacy-any project must be viable in financial terms before it can be transformed from paper to structure. Therefore, financial and technical evaluations are perceived to be essential. It is inevitable that any such implementation has to overcome the Herculean hurdle of the ever-present attitude of “no – change” mode.

Conservation of energy is nothing but to optimize the consumption. This leads towards the conservation. Energy audit not only accounts for energy conservation but also leads to substantial amount of monetary savings, which compel people to think about energy audit and conservation. Proper conservation of energy is the necessity of these days to
tackle the forth-coming energy crisis. In-fact, energy audit and conservation should go hand for successful energy balance.

1.16.1. Commencement

There is a saying in energy management “What is not measured cannot be managed” Measurement and data management are now key issues in Energy Management. The tools for the job are now available to manage energy in an efficient and cost effective way. Energy management of any industrial establishment is purely bases on the load estimates and planning of the distribution system. Energy Management is the stepping stone for the energy conservation and cost reduction process. The following Figure No. 1.9 shows Typical Energy Management Cycle.

**Figure No 1.9: Typical Energy Management Cycle**

![Energy Management Cycle Diagram](image)

1.16.2. Operational Management

Energy accounting, monitoring and control is the very first step to be observed in any of the energy conservation management. It is of great consequence to make any program of energy management to be successful.
1.16.3. Energy Management Techniques:

a. Self-Knowledge & Awareness among the Masses

For the successful Energy management & implementation, the knowledge of process & machine for the leader is very important. On the first instance, there is always a resistance from the user. There might be psychological mind blocks in the user’s mind. This needs to be made known & clarified. It is further more important to make the owner of the process understand the cost benefit of the energy conservation. Creating Awareness to the process owner can give most economic & low cost solutions to save energy. We have realized about 5% of energy saving just because of Awareness of the people.

e.g.: We can advertise the concept of “Zero Production = Zero Power consumption”. People can realize this concept and they can start switching off the Auxiliaries during Idling of main machines. Later on, we can introduce microprocessor-based timer to auto switch off auxiliary equipment during Idle period of machines.

b. Re-engineering and Evaluation

After utilizing the low cost or awareness concept, we need to do in depth study the process / machine. We need to ascertain, the scope & extent of Energy Conservation in the area under consideration. Evaluate the existing situation / employed technology in terms of process requirements & production capacity & capability. Sometimes, we do land into a situation of handicap with machine capacity & capability for the sake of Energy Conservation. It must not be done. Once it is established, that there is a potential of energy optimization. We need to start evaluation & re-engineering of the process / equipment. It may be terms of layout, motor capacity, types of starters employed, nature of loads etc.
c. Technology Up gradations

After having established the scope of energy conservation in the specified area, the latest technology availability is suitability, sustainability & pricing needs to be studied. Economics needs to be worked out like Payback period, Return of Investment, Quality of energy savings etc. Please remember “BETTER THE DIAGNOSIS, BEST WILL BE THE RESULT”

Increasing energy prices have led to design of equipment with higher efficiencies. More efficient boilers, motors, pumps, fan, refrigerators, Air Compressors, lamps are all available. Many of these uses more material, heat transfer area etc. and hence are more expensive than conventional equipment. The initial cost of equipment is negligible, compared to running costs and hence equipment selection should be bases on total life cycle costs, rather than initial cost.

i. High efficiency motors give better efficiency even at lower loads depending in type and size. Many textile mills use high efficiency motors,

ii. Many process industries have replaced in efficient aluminium or fabricated steel fans by moulded FRP fans with aero foil designs. Saving achieved are in the range of 15% to 40%,

iii. Compact fluorescent lamps (9 W to 18 W) can replace incandescent lamps of 4 to 5 times their rating. This results in saving 75% to 80% of energy,

iv. Many new centrifugal chillers with better heat transfer materials and designs give 0.6 to 0.8 KW/ton compared to 1.0 KW/ton for old chillers,