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Sustainable Energy for Manufacturing Industry An Indian Scenario

Prathamesh Chavan[1], Prashant Jain[2]

[1]Student, ME Mech (Energy Engineering), Department of Mechanical Engineering, K. J. Somaiya College of Engineering, Mumbai - India

[2] Faculty Department of Mechanical Engineering, K. J. Somaiya College of Engineering, Mumbai – India

Abstract: ***The well-being of society, economy and the environment depends on safe, clean, secure, sustainable and affordable energy. Much of the current energy supply is from the limited resources of fossil fuels which is deemed to be environmentally unsustainable. Being one of the fastest growing economies in the world, India faces formidable challenges in meeting its energy needs. To take on this challenge, India has to promote energy efficiency measures amongst the consumers and diversify its energy basket with renewable sources of energy. This paper is the outcome of an extensive literature survey on energy consumption by the Indian manufacturing sector and the importance of sustainable energy for the same.***

Keywords: Sustainable energy, energy conservation, energy efficiency, renewable energy sources.

1. Introduction

Energy is one of the crucial elements in the economic growth of a nation. India being a developing country, the energy demand is ever increasing and making provision for adequate energy supply is a great challenge owing to the huge investment required for this purpose. India has the fourth largest energy demand after the United States of America, China and Russia. As far as commercial energy use is concerned, India is the 6th largest energy consumer in the world with 3.5% of the overall. This demand is expected to become 2.5 times by the year 2020 i.e. a yearly increase of 16% [1]. India suffers from significant energy poverty and pervasive electricity deficits. In recent years, India‟s energy consumption has been increasing at a relatively fast rate due to population growth and economic development [2]. Though energy is essential for economic growth, the relationship between economic growth and increased energy demand is not always a linear one [3].

2. Indian Energy scenario

2.1 India's Energy Mix

Energy scenario of India shows that coal dominates the energy mix in India, contributing to 58% of the total primary energy production, followed by hydro, renewable, gas and oil sources. The total power generation capacity in India in March 2013 was 159 GW. Of this, 67.8% was fossil-fuel-fired power plants (coal, gas, and diesel), 17.7% hydropower, 2.1% nuclear power, and 12.3% renewable energy. The following figure shows the installed power generation capacity in India [4].

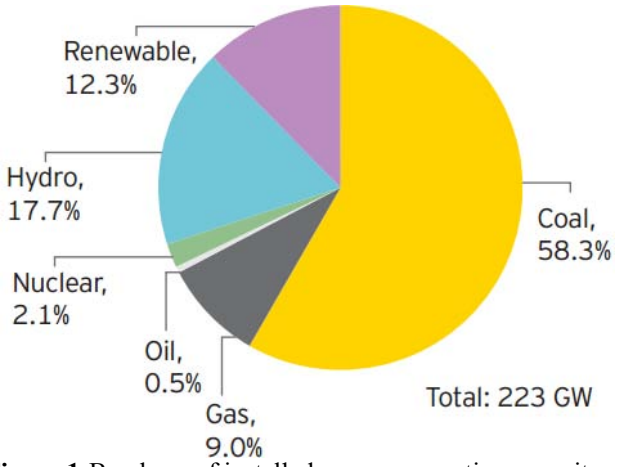

Figure 1: Break-up of installed power generation capacity of India
(Source: CEA, Ernst & Young analysis; as on 31 March 2013)

2.3 Use of Renewable Energy Sources

Power generation from renewable sources is on the rise in India, with the share of renewable energy in the country‟s total energy mix rising from 7.8% in 2008 to 12.3% in 2013. India had about 25.1GW installed renewable energy capacity as on 31 March 2013. India accounts for 68% of the capacity, making India the world‟s fifth largest wind energy producer. Small hydro power (3.6GW), bio-energy (3.6GW) and solar energy (1.7GW) constitute the remaining capacity. Although the share of renewable energy in the generation mix has been rising over the years, India still has untapped renewable energy potential [4]. There is a potential of around 90,000 MW for power generation from different renewable energy sources in the country, including 48,561 MW of wind power, 14,294 MW of small hydro power and 26,367 MW of biomass and 657 GW of solar power [5].

2.4 The Challenge of Energy Security

The well-being of society, economy and the environment depend on safe, clean, secure, sustainable and affordable

energy. In 2011 India‟s per capita energy consumption was 0.6 toe, much lower than the world average of 1.88 toe. It‟s obvious that the country‟s energy demand is far from saturated [6]. According to the Planning Commission estimates in the 12th five year plan, India‟s primary energy consumption will grow up to 80 per cent by 2022 and the energy import requirement will also increase, by 77 percent [7]. As far as commercial energy use is concerned, India is the 6th largest energy consumer in the world with 3.5% of the overall. This demand is expected to become 2.5 times by the year 2020 i.e. a yearly increase of 16% [8]. Energy consumption worldwide is expected to grow 56% between 2010 and 2040, with half of the increase attributed to China and India [9].

As per present estimate, 85% of electric power generation in India is dependent on oil, natural gas and coal. Even though India has abundant quantities of coal, it is constrained to regional locations and has high ash content, affecting the thermal efficiency of power plants. The high energy demand marred with the limitations of conventional energy, emissions of the harmful greenhouse gasses (GHG) and serious pollution problem is the major challenge facing the country.

3. Sustainable Energy for India

3.1 What is Sustainable Energy?

The concept of sustainable energy has evolved for a livable future, where the three dimensions of sustainable development i. e. societal, economic and environmental wellbeing of the planet earth are achieved while keeping a balance with nature. Sustainable Energy is defined as the utilization of energy in such a way that it meets the energy requirement of the present generation without compromising the energy needs of the future generation. It is the energy which can be completely refilled or reloaded within a human lifetime and has no negative impacts to the environment. It‟s not about using only renewable form of energy but also following some energy conservation and energy efficiency measures so that the total energy consumption is reduced [8]. Until now sustainability was only about analyzing the availability of resources compared to the rate at which it is utilized but today in the world of Sustainable development where there is a growing serious concern of global warming due to the emission of GHG, some other aspects like environmental effect and the question of waste generation also are considered [10].

3.2 Significance of Sustainable Energy for India

Access to energy is a necessary element to achieve many development goals, that extend far beyond the energy sector, such as eradicating poverty, increasing food production, providing clean water, improving public health, enhancing education, creating economic opportunity, and empowering women etc. [11]. The shift of energy mix of India towards coal compared to oil and gas has led to rapid increase in the emission intensities of the country. So, to curb the increasing GHG emissions resulting from the human development activities we need to address our energy needs on a sustainable basis.

According to the BP Energy Outlook 2035, as depicted in the following charts, most of the increase in the global energy consumption in coming decades will happen in the rapidly developing countries like India. The coal, now surging as an international fuel source, is anticipated to decline beyond 2020 and the share of renewables in the global energy mix will be continuously on the rise.

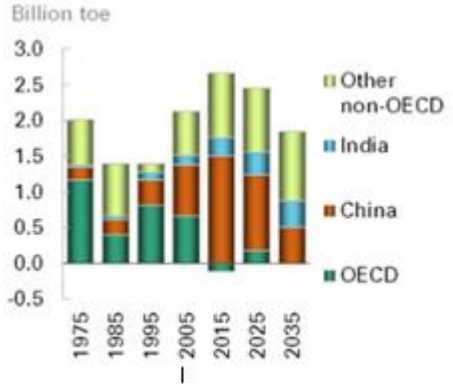

Figure 2: Regional increments of energy consumption growth over the decades to 2035

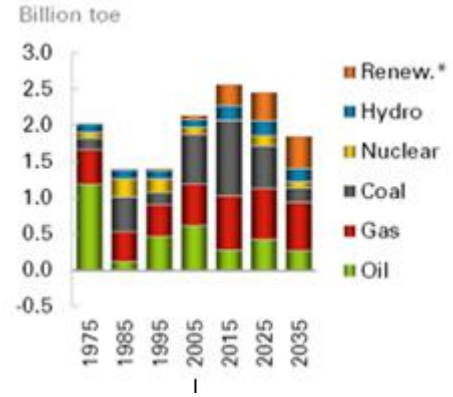

Figure 3: Projected ten-year incremental changes in fuel supply through 2035
(Source: BP Energy Outlook 2035)

Energy use in India is highly intensive and happens to be amongst the highest in the world, whereas the per capita consumption of energy is lowest compared to the OECD countries and even most of Asian countries [13]. In this scenario, for India, the energy sustainability seems to be the only way out. To conclude, we may say that development is not possible without energy, and sustainable development is not possible without sustainable energy [14].

3.3 Sustainable Energy for Manufacturing Industry

Manufacturing is a highly energy intensive industry and demands huge amount of on-sight and off-site power, large amounts of process energy for the manufacture of goods, and non-process energy to maintain facilities. Industrial manufacturing companies have great opportunity to increase business value from energy efficiency and renewable energy measures [14]. All the industry owners and commercial and residential energy consumers are thus strongly recommended to take strict action toward three critical

objectives i.e. energy conservation, energy efficiency and the inclusion of renewable energy in their energy mix [11].

When choosing energy fuels and associated technologies for the production, delivery and use of energy, it is essential to take into account economic, social and environmental consequences. In other words, the consumers need to determine whether current energy use is sustainable and, if not, how to change it so that it is [15]. Some of the guidelines for achieving the target of sustainable energy for manufacturing sector are improved energy efficiency of existing technologies, reduction of energy demand and wasted energy, use of existing renewable energy technologies and research and investment in new technologies [16].

4. Sustainable Energy for India's Manufacturing Sector

4.1 Overview

In India the manufacturing industry is one of the top consumers of natural resources and produces extensive carbon emissions that create the need for a sustainable manufacturing process [14]. Almost one-third of the total energy demand in India is consumed by the manufacturing sector. With the increase in population and its standard of living, the energy demand from manufacturing sector will also increase [17].

Today Indian industry is facing a twin challenge of meeting its energy demand along with minimizing carbon emissions to bring a sustainable and steady growth. India needs to sustain an 8% to 10% economic growth rate over the next 25 years if it is to eradicate poverty and meet its human development goals [18]. A way to tackle these challenges is to fulfill energy demand, as far as possible, by ensuring measures to promote energy efficiency and harnessing and utilizing viable alternative energy sources.

4.2 Implications for India's Manufacturing Sector

In industry power required for processing is mainly taken from the grid. But there are some processes which need uninterrupted power supply and these manufacturing units cannot totally depend on the power available from the grid which not reliable due to frequent power cuts. Such power cuts may turns into losses to them. To avoid this, they set up their own expensive power generating units called the backup diesel generators. These generators are energy inefficient in use and lead to pollution. Also their use increases the final product cost due to increased cost of production. Also the current tariff structure of India puts industries to a disadvantage. Heavy electrical tariffs are imposed on industry and commercial sector to cross subsidize the agriculture, residential and public sectors. Due to this, agriculture and public sector have been observed to be less concerned with implementing energy efficiency and energy conservation measures [19].

4.3 Status of Sustainable Energy Measures in Indian Industry

The manufacturing sector in India being one of the major consumers of energy is the one where there is a need of taking some strict energy efficiency measures in order to achieve an overall development of the nation. A number of research and development activities are carried out, technologies are developed and energy saving measures are introduced to promote energy efficiency in industries. In India, there are several industries which are not aware of or they do not have access to this information [10].

In India, the „Energy Conservation Act 2001" has become effective and the Bureau of Energy Efficiency (BEE) has been operationalized from 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 2001. The EC Act was amended in 2010.

4.4 Energy Management

A concise definition of Energy Management is: "The judicious and effective use of energy to maximize profits (minimize costs) and enhance competitive positions" [20]. In a more comprehensive manner it may be defined as: "The strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems".

The objective of Energy Management is to achieve and maintain optimum energy procurement and utilization, throughout the organization and to minimize energy costs / waste without affecting production and quality and to minimize environmental effects [21]. The three aspects of Energy Management for improving energy performance of a manufacturing industry are Energy Conservation, Energy Efficiency and use of Renewable Energy.

Energy Conservation and Energy Efficiency are separate, but related concepts. Energy efficiency is achieved when energy intensity in a specific product, process or area of production or consumption is reduced without affecting output, consumption or comfort levels. Promotion of energy efficiency will contribute to energy conservation and is therefore an integral part of energy conservation promotional policies. Energy efficiency is often viewed as a resource option like coal, oil or natural gas. It provides additional economic value by preserving the resource base and reducing pollution.

5. Energy Conservation in India's Manufacturing Industry

5.1 Energy Conservation

Energy Conservation in manufacturing is defined as "An attempt to reduce the energy used for manufacturing purposes without affecting the quality of goods manufactured." It is further defined as "the strategy of adjusting and optimizing energy using systems and

procedures so as to reduce energy requirements per unit of output while keeping the product cost constant or reducing total costs of providing the output from these systems" [3].

Coal and other fossil fuels, which have taken three million years to form, are likely to deplete soon. In the last two hundred years, we have consumed 60% of all resources. For sustainable development, we need to adopt energy efficiency measures. Today, 85% of primary energy comes from non-renewable and fossil sources. These reserves are continually diminishing with increasing consumption and will not exist for future generations.

Energy conservation is achieved when growth of energy consumption is reduced, measured in physical terms. Energy Conservation can, therefore, be the result of several processes or developments, such as productivity increase or technological progress [21].

5.2 Tools for Energy Conservation

Some of the effective tools of energy conservation and management are Knowledge Dissemination, Energy Audit, Energy Education and Regulations and Energy Information Technology [21].

1) *Knowledge Dissemination:* This includes implementing policies and programs on creating mass awareness regarding energy conservation. In order to achieve this, seminars could be conducted among the cluster of manufacturing engineers to exchange the latest information in specialized fields. Cluster can be formed according to the geographical location such that those companies should be nearer to each other and also the manufacturing equipment's used by them are similar. Available methods and techniques like video films, radio, TV, satellite communication and networking, posters, advertising in public facilities like parking space, market, and stadiums can be used.
2) *Energy Audit:* As per the Energy Conservation Act, 2001, Energy Audit is defined as "The verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption" [3]. The basic objective of Energy Audit is to determine the number of ways to reduce energy consumption per unit of product manufactured or to lower its total manufacturing costs. Energy Audit provides a standard for utilizing energy in the industry and also provides the guidelines for making more effective use of the available energy without harming the nature. The type of Energy Audit to be performed depends on the function and type of industry, depth to which the final audit is needed and the potential and magnitude of cost reduction desired. The Energy Audit is classified as Preliminary Audit and the Detailed Audit. In preliminary audits mostly the already existing or easily available data are used for analysis and easy and low cost energy efficiency measures are identified. Also the areas where detailed audits are required are also found. In Detailed Audit the energy consumption of all the equipment's are estimated where the key elements is the energy balance. This offers the most accurate estimate of energy savings and cost.
3) *Energy Education and Regulations:* Energy regulations are essential for any successful energy policy. Energy management includes number of regulations for energy consumption and direct/indirect electrical loads. Energy education is another way to build energy conservation culture amongst industry people and society. Such education schemes may include energy basic principles, conventional and renewable energy sources, consumption loads and the relevant environmental effects etc.
4) *Energy Information Technology*: Information on energy is required so as to help the researchers to develop new technologies which will be more energy conservative compared to the existing ones. To achieve this, there should be an energy information bank where the information regarding the existing technology is easily available. Establishing such informative library can help the researchers, students and public to come out with new and improved technologies.

6. Barriers to Energy Conservation in Manufacturing Industry

6.1 Major Constraints

More and more manufacturers are highly motivated to improve their energy and resource efficiency. In fact, many of them proactively search for assistance and solutions to understand how the energy and materials are consumed within the facility as well as to identify opportunities for improvement [24]. In spite of the information available in literature, Indian manufacturers are lacking behind in the adoption of these technologies. Reasons behind this are some of the barriers explained below which need to be eradicated .

1) *Resource Constraints:* Financial resource is the biggest constraints for any manufacturer to implement energy and resource efficiency measures. The payback period for a major investment is often expected to be shorter than a year. This certainly pressures the amount of saving and the budget for the implementation. Thus, the resource constraints need to be clearly communicated prior to taking any action.
2) *Production Constraints:* Any change in a manufacturing facility may lead to the overall performance change at the system level such as throughput rate, inventory level, on time delivery, etc. These performances are closely linked with the customer service level, which should not be compromised. During the implementation process, the production may also be affected due to set-up activities, such as, connection of energy meters, installation of new devices, etc. These activities need to be planned with cautious in order to minimize the interruption to the production.
3) *Technology Constraints:* Retrofitting options can face with technological constraints to fit into the existing production systems in terms of space, capacity, operation etc. These constraints not only limit the number of feasible options but also increase the risk of future disturbances into the ongoing production system. As a result, these need to be investigated and integrated

explicitly prior to the final recommendation for decision makers [23].

4) *Other Barriers:* Limited information amongst the manufacturers about the benefits of energy efficiency investments and technologies, lack of enforcement of standards, codes, and labeling on the part of state and unwillingness of the firms to dispose their inefficient products are some of the major barriers to energy conservation in Indian manufacturing industry. Competing objectives in complex planning situations involving new investments and high transaction costs in legal and technical matters and associated transactional complexities, like non-standardized deal structures and substantial technical content of project appraisal, development, and monitoring etc. also forbid the manufacturers from such endeavors [22].

7. Energy Efficiency in India's Manufacturing Sector

7.1 Overview

Extensive carbon emissions are because of energy inefficient practices carried out in manufacturing industry. The term Energy Efficiency is widely used but not always well understood. It is defined as the ratio of output to input energy consumed by the system. The system can be any of those used in manufacturing sectors like motors, compressors, pumps, a building, an industrial sector or any energy conversion device. Energy savings are expected to be achievable from increasing both the energy efficiency of production and the logistic processes, as well as in innovative energy monitoring and management approaches, leading industries to a way of producing "more with less" [16].

7.2 Inefficient Technologies and Procedures

The reasons for failure in realizing energy efficiency include lack of time, lacking transparency on energy consumption, lacking capital for investments and divided responsibilities within a company [28]. Besides suffering from the energy supply shortfalls, the Indian manufacturing sector is also proved to be inefficient in technologies and procedures. According to estimates from a study carried out by the BEE and National Productivity Council (NPC) in 2009, there is a potential of energy saving from around 7% to 30% across different sectors. This implies that energy efficiency offers huge scope of improvement in India and holds the key to solving India‟s energy problems to a great extent [30].

7.3 Improving Energy Efficiency

To focus on making Indian manufacturing industries energy efficient, the various processes involved in the production chain of manufacturing industries needs to be energy efficient [18]. Almost all processes which range from production to packaging and then finally to transportation are energy consuming. The primary methods for reducing energy consumption in Industrial processes are installation or retrofitting new equipment or modifying the existing processes to make them more energy efficient throughout their life span.

8. Use of Renewable Energy in India's Manufacturing Sector

8.1 Overview

Renewable energy is the inevitable choice for sustainable economic growth [30]. Also, in recent years due to the increasing concern about global warming caused by the emission of greenhouse gases (GHG), the world is slowly moving towards the use of Renewable sources to meet their energy needs. The renewable sources are freely available, will never get depleted and they cause no harm to the environment [31]. Obviously India should move towards clean sources of energy which will not only cut down the harmful emissions rates but also will lead to a sustainable development of the country.

8.2 Existing Energy Mix in Manufacturing Industry

In spite of their number of advantages, the renewable energy sources are still not much used in manufacturing industries Reason behind this are the heavy investment required to set up this technology, lack of awareness about the benefits of the technology, ignorance, lack of expertise and long pay back periods [29]. The energy demands of manufacturing sector are mostly fulfilled by the conventional non-renewable sources like coal, petroleum and diesel. They need to be replaced by renewable energy sources such as solar, wind, tidal, bio diesel etc. However no major investments in manufacturing sector have been found until now, as far as use of renewable energy is concerned [30, 31].

8.3 Some Common Renewable Energy Options

Renewable energy can be used in manufacturing applications in many ways. Some of the options are as biomass for process heat, biomass for petrochemical feed stocks, solar thermal systems for process heat and heat pumps for process heat. Several other options also are there. But they are not very common and make just a niche contribution to an industry‟s energy mix. Some of such options are conventional geothermal heat, run-of-river hydro, wind power and combined heat and power plants.

9. Conclusion

The nature of India‟s energy scenario and the extent to which India can meet the challenge of climate change in the coming decades will largely depend on the energy use choices and policies adopted. Manufacturing units, being highly energy intensive, should be scientifically planned according to local ecological conditions and properly developed based on conservation culture in order to minimize their negative effects on the ecology and the environment. The renewables being the clean source of energy are the only option for sustainable development. Presently in India only a fraction of the aggregate potential in renewables, and particularly solar energy, is being utilized. The achieved wind power capacity, installed biomass power and small hydropower capacities are also less than their potential. There is a large amount of renewable energy resource available in India which needs to

be harnessed in a planned and strategic manner to mitigate the gap between demand and supply. Also, India can demonstrate the use of sustainable technologies and processes to the developing countries and help them in adopting the same. This will not only lead to a low carbon future for the planet but will also pose a moral pressure on the industrialized countries to contribute more for the same.

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