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IMPLEMENTATION OF CLEANER ENERGY AND ENERGY CONSERVATION ON A GLOBAL SCALE: A REVIEW

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Abstract

Global issues namely global warming, greenhouse gas (GHG) emissions; waste generation and energy security are escalating with the passing time. Manufacturing industry remains to be major contributor to these issues and it is a matter of concern. The manufacturing industry on the contrary plays a significant role in boosting the nation's economy and global economy at large. These issues can be resolved by taking a paradigm shift and adopting the measures to mitigate these issues. These issues could be mitigated by implementing long term strategies such as adoption of clean energy and energy conservation practices in manufacturing processes. This paper deals with energy conservation measures and adoption of clean energy in manufacturing industry and its associated long term positive impacts on global manufacturing industry at large.

Keywords: clean energy, energy conservation, energy security, global warming, greenhouse gas, global manufacturing, and paradigm shift.

I. INTRODUCTION

Manufacturing industry in the process of conversion of raw materials into finished goods consume substantial amount of energy, the energy consumption pattern shows a steady increase in levels of energy consumption. Major proportion of energy derived for processes is from fossil fuels which is a serious concern. The environmental impacts of fossil fuels have long term implications on the environment such as GHG emissions, global warming and smog. Long term strategies such energy conservation measures and use of sustainable and clean energy should be the order of the day to surmount the issues of energy consumption and environmental impacts. Cost-effective methods to enhance energy efficiency in the economy are to merge investments in energy-efficient technologies with the backing of superior energy management implementations [1]. The energy saving setting comprise judicial use of energy policies in all economy sectors and utilization of combined heat and power arrangements, which are capable of augmenting energy savings from the autonomous power plants at large [2]. The Energy efficiency comprises preserving a deficit resource; improvising the technical efficiency of energy conversion, production, transmission as well as end-use machines; substituting costlier fuels with that of cheaper ones; reducing the harmful effect of energy production and consumption event on the surroundings. Energy conservation is a quantifiable resource by itself that contends economically with existing energy supply alternatives [3]. The large-scale renewable energy adoption proposals should contain strategies for combining renewable sources in coherent energy systems affected by energy savings and efficiency practices [4]. Energy conservation practices can save significant quantities of energy without giving up production and can be regarded as an alternative energy source [5]. The Energy conservation intends to offer solution to the crisis related to resolving flaws in industry's power supply service. It can affect industry's consumption energy in physical as well as monetary aspects, decrease in energy consumption related to production of certain kinds of goods, etc. Hence, if such energy economy policy is implemented, the factory management team intends to resolve existing problems in power supply process [6]. One of the aims of energy conservation practices is to increase the utilization of the secondary energy to the extent possible and thus reduce the needs for primary purchased energy as well [7]. The efficiency optimization is crucial not specifically to electrical systems, but also to lessen cost and to reduce global warming process [8]. The developments in technologies from the viewpoint of power generation; renewable energy utilization and alternative energy technology growth are on the rise to fulfill energy demand of the industry [9]. Energy conservation could be the top solution for the growing energy demand. Energy conservation is cutting down the energy consumption by using a smaller amount of an energy service [10]. The consumers with precise insights of energy consumption and savings possibly are better competent to recognize the actions that save the major portion of energy, as an initial potential measure in the direction of behavior change and reduced GHG emissions [11].

Global policy makers need to strategize and suggest measures to improvise the prevailing situation by suggesting measures and enforcing regulations on the use of cleaner energy to the extent possible and energy management techniques such as energy conservation to combat these issues. Energy consumption reductions can be accomplished by minimizing the energy demand, by judicial utilization of energy, through recovering heat and the utilization of more green energies [12]. The exploitation of renewable resources pooled with efficient supply and usage of fossil fuels with cleaner technologies, could assist reduce the environmental impacts of energy utilization [13]. Clean energy manufacturing entails reduction of energy and environmental impacts, use and disposal of manufacturing produce which vary from elementary commodities namely metals and chemicals to sophisticated products such as automobiles and wind blades, it improvises energy use and offer economic- wide reductions in GHG release by means of changes in energy utilization facilitated by the growth of new materials and process technologies [1]. The clean Energy Manufacturing Analysis Center (CEMAC) termed clean energy technologies as the technologies that produce energy services with less environmental impacts than conventional technologies or enabling existing technology to operate more efficiently [12]. The clean energy changeover calls for a co-evolution of creativity, investment, and strategies for promising energy storage technologies [14]. The policies that describe the Clean Energy Future (CEF) settings comprise financial inducements, voluntary programs, guidelines and research and development, several policies were chosen based on their potential to reduce carbon dioxide release [15].Coordinating economic and energy strategy by utilizing clean energy technologies is a promising trend. The efficiency of these new hybrid multi-goal strategies is worth examining [16].The changeover towards a low carbon society is a main challenge that will necessitate progress in innovation research and our perception of technological transformation and innovation policy, in particular; the transformation of the energy system will necessitate a proper understanding of the nature of technological transformation associated with renewable energy technologies, considering both theoretical conceptualizations as well as empirical support [17]. The Clean energy deployment is of strategic significance for any country, since it may offer the basis for energy autonomy and security, green economic development, low ecological impact and sustainable resource utilization [18].

Clean energy manufacturing possibly addresses some of the aspects of environmental impacts, energy efficiency and efficiency of utilities of manufacturing. It proposes the use of clean manufacturing in the manufacturing processes to reduce environmental concern and in some cases reduction in operation costs. Energy conservation practices namely waste heat recovery systems, reuse, recycling, energy auditing, material flow analysis (MFA) and life cycle assessment (LCA) result in improving the energy use pattern in manufacturing industry. The adoption of clean energy coupled with energy conservation practices would be able to produce better results and make a difference in global business at large.

II. NEED FOR CLEAN ENERGY AND ENERGY CONSERVATION PRACTICES IN CURRENT MANUFACTURING SCENARIO

Manufacturing industry (product and process) is a major player in boosting the global economy. Manufacturing industry emit GHG as a part of manufacturing operations. As per International Energy Agency the iron and steel industries account for close to 20% of energy consumed as compared to all other industries around the globe and about 30% of world's direct industrial CO_2 release [13]. The speed and degree of the growing fossil-fuel consumption have resulted in a new urgency to adopt the full range of clean energy technologies, from those that lessen conventional contaminants namely sulphur dioxide (SO2) and nitrogen oxides (NOx), to emerging technologies with higher efficiency and the ability to significantly cut down carbon dioxide (CO2) emissions [19]. To achieve the solutions to environmental problems that the world is facing in the present situation, probable lasting actions projected to achieve global sustainable developments are needed, today, the world needs clean energy revolution to decline requirement towards fossil fuels; such a crucial clean energy revolution might improve the implementation of renewable energy technologies (RETs) to a greater extent [20]. The urge to expand renewable and further clean energy technologies is not at all being driven merely by environmental problems; these technologies are turning out economically competitive also [21].The speed of innovation and distribution of clean technologies can perform to either support or offset the legacy of climate alleviation strategies [22]. The well deserved design and implementation of widespread renewable energy strategies, nevertheless, has turned out to be a difficult job, given dynamic worldwide market trends and the need for an intricate set of governing capabilities locally [23]. The energy transition will necessitate a synergetic innovation process customized to the requirements of individual renewable energy and energy efficiency technology as a extensive variety of methods will be needed across all sectors of the energy system [24]. To be able to satisfy our future needs, we therefore have to invest in all viable energy options compatible with our environment [25].

Hence the manufacturing industry consumes substantial proportion of energy and major portion of it is derived from fossil fuels, the focus should be on cleaner energy and in improving energy efficiency. In addition to GHG emissions, manufacturing industry contributes to waste generation in the form of solid, liquid and gases from several chemical, textile, power generation and iron and steel companies.

Energy generation processes have a great potential in total product life-cycle to minimize negative environmental impacts, consume natural resources as well as in focusing on safety of employer, consumer and surroundings [26]. Manufacturing industry requires energy for different process such as machining, process heating, drying and cooling. Findings from climate and sustainability research indicate that severe lessening of ecological "footprint" required for maintaining ecosphere could be accomplished by fundamentally reorganizing current patterns of production and usage [27].

It is evident that strategies are required to reduce the energy consumption and environmental impacts of manufacturing industry; this could be executed by following energy conservation practices for reducing energy consumption levels and implementation of cleaner energy for reducing environmental impacts.

III. ADOPTION OF CLEANER ENERGY AND ENERGY CONSERVATION PRACTICES: A PARADIGM SHIFT

Traditional manufacturing systems need to shift from traditional approach to cleaner energy and energy conservation approach to mitigate these issues. These measures are long-term in nature and require an integrated approach to implement these schemes. There are several techniques that can be developed as energy conservation measures as a solution to energy consumption in manufacturing industry. Some of them are discussed below:

Waste Heat Recovery System: The process of recovery and waste reduction produced in manufacturing system provides an opportunity to lessen manufacturing energy utilization and associated release of contaminants [1]. The heat can be recovered following heating processes otherwise as a derivative heat that is generated when processes convert energy present in fuels into mechanical work or else electric energy. This system improvises the energy use, conserve energy and improve the system efficiency [28].

Combined Heat Power (CHP): These technologies offer manufacturing facilities with technique to reduce energy costs and emission and in providing more resilient and reliable energy [1]. The Combined Heat Power (CHP) is implemented at the place where energy is needed and hence it reduces the requirement for grid system reinforcement, visual effect of huge power stations and thermal pollution produced by huge, old and inefficient power stations [29].

Material Efficiency: This system recognizes energy required to produce commodity products and reduces the quantity of material needed for manufacturing as well as processing and results in net energy savings [7].This method identifies material to be chosen that fulfills the manufacturing requirements, reduces energy requirements during manufacturing and other parts of supply chain.

Life Cycle Assessment (LCA): This technique performs process improvement to reduce waste, improves efficiency, reduce toxics and save cost across their products life cycle [31]. It takes into consideration the different phases of manufacturing from design, raw-material supply, finished goods, usage and end of life. Energy and cost assessment are carried out at every stage of flow and scope for improvement with respect to energy, cost and material savings are identified.

Material Flow Analysis: A total understanding can be achieved through tracing how materials ow during manufacturing supply chains and where resources namely materials, water, and energy are used throughout product life cycles, practicing strategies to augment material efficiency will lessen the material use intensity of supply chains, and consecutively offer additional opportunities for energy efficiency [1]. Material flow analysis results in optimization of energy, material and resources and provides a valuable input to manufacturing process as a whole.

Additive Manufacturing (AM): These technologies significantly reduce material waste during manufacturing of the part. Analysis of life cycle energy impacts of particular product find that AM possess the ability to reduce energy use and environmental emissions [31].

Most of the manufacturing companies across the globe use energy for their process which are not sustainable and in clean in nature, as a result produces significant damage to ecology. Therefore, an assessment is required to identify the energy requirements for various processes of manufacturing as well as possibility of substitution of conventional sources to cleaner energy sources to fulfill the energy requirement of the processes. Some of the energy requirements and possible energy alternatives that can be used are discussed below:

In the entire manufacturing sector consumed 127 EJ of final energy in 2010, which is about a third of global energy demand. The total use comprises electricity, feedstock for feedstock for petrochemicals production, blast furnace and coke ovens [1]. It is clear from the above statistics that the energy requirements of manufacturing industry is substantial and demands a clear cut strategy to replace the existing energy source with a more cleaner, efficient and economically viable source to mitigate environmental and energy security issues. It is estimated that the process heating alone liable for roughly 61% of manufacturing and end energy utilization on annual basis and energy required for this process is got through combustion, electricity, steam and fuels namely natural gas, coal biomass and fuel oils [1]. These process requirements can be fulfilled by a cleaner energy such as biomass, solar thermal and geo-thermal technologies.

Total use (22EJ) accounts for roughly three- quarters of approximated total extra renewable energy potential in worldwide industry (28 EJ) and inexpensive biomass offers basis for renewable heat generation processes (14EJ), in addition solar thermal and geothermal technologies provide potential in producing low and medium temperature process heat as a latest capacity estimated to be roughly 2.5 EJ and 1.1 EJ respectively [30]. Process requirements require energy to cater requirements such as space heating, drying, washing spray painting etc. Cleaner energy can be employed to meet these requirements. In industry, five sectors namely transport equipment, machinery, mining and quarrying, food and tobacco, textile and leather use a significant use portion of process heat at a temperature less than 4000C and therefore solar thermal systems has potential to meet their process requirements and can be benefited from implementation of these systems [32]. Deployment of such cleaner energy has two prospects: it reduces the dependence of fossil fuels and reduces emissions associated in the process. After attaining a large proportion of intermittent resources in combination with CHP and savings, the creation of sustainable energy policies turned to be a matter of introducing and augmenting flexible energy technologies and producing combined energy system solutions [26].

One-third of final energy usage of pulp and paper sector derived from biomass and waste with a highest of 82 % attained in Brazil [33]. Biomass can be used in high energy intensive sectors like iron and steel and cement. In addition to process heat, biomass technologies such as anaerobic digestion and gasification can be used to fulfill the energy requirements to some extent. Biogas produced from anaerobic digestion after undergoing the treatments such as cooling and cleaning can be directly supplied in gas distribution pipelines or can be used in gas engines and gas turbines for power generation purposes. Gasification process produces synthetic gas (producer gas) which can be used in gas turbine plant for power generation and for meeting the process heat needs as well. Even geothermal source can be used to cater the process heat requirements, but the important consideration is that the plants needs to be located in the vicinity of geothermal reservoir which is many a times is not feasible.

IV. CHALLENGES ASSOCIATED WITH CLEANER ENERGY TECHNOLOGIES

The cleaner energy despite of its contribution to manufacturing industry in fulfilling the range of needs is not free from limitations and challenges. The three cleaner energy technologies we referred during the course of discussion are solar thermal, geothermal and biomass energy. Referring to geothermal source, as discussed earlier in order to exploit this resource the plants needs to be located close to the geothermal source which in many cases is a ruled out option. The geothermal plants releases solids and non-condensable gases and also results in land subsidence and these plants needs to be more efficient and should be provided to the customer in a more affordable manner.

The major limitations of biomass are resource availability, low energy content, economic viability and competition from other energy sources. The economic viability is defined by energy density (bulk), transportation costs and difficulty involved in transportation. Solar thermal sources are bounded by limitation of high initial cost, low operation hours owing to the dependence of solar energy and requirement of large area for installation.

V. CONCLUSIONS

It is imperative that energy conservation and clean energy provide affordable and feasible solutions to the problems posed due to energy consumption and environmental impacts of manufacturing operations. In the view of rising shortage on one hand and shortage of resources on the other hand, the best cost-effective choice accessible to any nation to bridge the gap amid demand and supply of electrical energy is energy conservation and management [27]. These measures obviously come with a cost which is justifiable by the long-term positive impacts on environment and energy consumption patterns because of adoption of these practices. Although some sectors of manufacturing industry have already implemented these practices, yet the number of which need to improve in the years to come to handle such sensitive issues in the most effective manner possible?. Global issues of manufacturing such as global warming, GHG emissions and energy security could be handled effectively by implementing practices of energy conservation and adoption of cleaner energy. The data and statistics of energy of manufacturing industry and potential of cleaner energy suggest that energy consumption patterns and environmental impacts can be mitigated by accurate assessment and evaluation measures in these aspects.

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