



GREEN MANUFACTURING FOR SUSTAINABLE CLIMATE CHANGE MITIGATION

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ABSTRACT

Different approaches have been adopted to advance the course for climate change adaptation and mitigation. There should be deliberate effort to re-direct production / manufacturing towards climate change conservation concerns. Recently, the world is going green ranging from greening TVET, green economy, green collar jobs, and green manufacturing. This work is a review of the elements of this subject matter and its impact to climate change mitigation and adaptation struggle. It considers social partnering and social dialogue on green manufacturing, the career structures in green manufacturing with respect to green collar jobs, merits, de-merits and inhibitors of green manufacturing. The work review and highlights global strategies for enhancing green manufacturing and its implications to global climate change progress. Based on this a conclusions and suggestions was made on the subject matter as it relates to global climate change adaptation and mitigations.

Keywords: green manufacturing, climate Change, green economy, greening TVET, green collar jobs.

INTRODUCTION

The environmental crisis the world is facing today is originated among others from the current unsustainable production and consumption patterns, such as overconsumption of natural resources, massive use of fossil fuels in industries, energy low efficient buildings and transports, deforestation, unsustainable agriculture and lack of appropriate management of waste. However, while the environmental crisis represents a threat for societies due to the depletion of the ozone layer, the policies aimed at combating it provide a unique opportunity for providing green jobs for all, improving the livelihoods and rights of the most vulnerable peoples and communities. Moreover, it provides a chance to achieve social progress for all and transform a socially, economically and environmentally unsustainable system (International Labour Organization ,2012).

Historically, steam and coal were the first energy source that powered the first industrial revolution which made it easier and faster to drive the printing and textile companies and the railways that bridged nations and continents. The second industrial revolution relied on oil or fossil fuels as the prime energy source that powered most manufacturing and servicing companies globally bringing rapid industrial growth. The manufacturing sector consumes a lot of energy and other resources and emits large amount of green house gases (GHG) which increase environmental problems like climate change causing global warming, global dimming and environmental degradation. According to Naomi (2004) increase in concentration of atmospheric greenhouse gases such as carbon (IV) oxide tropospheric ozone, chlorofluorocarbons (CFCs) by one third has caused significant increase in global temperature and hence global warming. Boutkhil (2010), problem of climate is regarded as a global environmental issue and an important scientific fact and a problem from which the globe has been suffering for decades .Climate changes which are currently occurring in the world are one of the most important concerns of countries, whether developed or developing, because of the global warming and its repercussions and negative effects that affected various areas and human dimensions. Also, the problem of misuse of natural resources and the degradation of the environment has become a critical challenge facing all the governments of the world.

Sustainable Development Goals (SDGs) partners with Intergovernmental Panel on climate change (IPCC), United Nations Development Programme (UNDP), United Nation Industrial Development Organization (UNIDO),and the United Nation Environmental Programme(UNEP) on reduction of global poverty and inequality through sustainable development of nations through policies formulations and regulations of GHG(Green House Gases) emissions. This work highlights global strategies for enhancing green manufacturing and its implications to global climate change progress.

GREEN MANUFACTURING ORIGIN AND OVERVIEW

According to Rehman and Shrivastava (2013) the concept of Green Manufacturing (GM) originated in Germany in the late 1980's and early 1990's, they had established an effectively global manufacturing standard instilling that, any company wishing to compete globally must start making products that will comply with the Green regulation of European market. From the 1980s, activities in sustainable manufacturing started to focus on waste reduction in production. After this, the paradigm for sustainable manufacturing had been changed from process oriented to product oriented; mainly focuses on reduction of resources, energy and toxic materials, as well as development and use of renewable materials expressed Seliger et al. (2008). Similar view was given by Fischer et al.(1997) who advocated numbers of ways organizations have addressed these concerns, few of them are designed for reusability and recycling, minimizing waste, emissions and raw material consumption.

According to Bylinsky (1995) and Norberg-Bohm (1999) GM is more than using Green resources; it is based on manufacturing for reuse, design for disassembly etc. Ramakrishnan (2006) states that GM is about designing products using design for environment (DfE) principles, manufacturing them with eco-efficient processes, delivering them to the customer with the least environmental impact and applying 'cradle to cradle' approaches for handling end of life (EOL) products. Mohanty and Deshmukh (1999) and Southworth (2008) stresses on reducing harmful waste. Melnyk et al. (2002) emphasis on managing the flow of environmental waste with the goal of minimising environmental impact while also trying to maximise resource efficiency.

GREEN MANUFACTURING DIFINATIONS , OBJECTIVES AND SIGNIFICANCE

Man's quest for survival and wealth or social prosperity is the driving force for the exploration and exploitation

of the earth's natural resources. This exploration and exploitation must be sustainable; else we survive now and are destroyed tomorrow. Production/manufacturing has to take into considerations climate change environmental conservation awareness, for it to be even futuristic itself. Mendler et al. (2005) defined green manufacturing (GM) as meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. According to Cortellini (2001) GM is a method of manufacturing that minimizes waste and pollution, slows the depletion of natural resources as well as lower's the extensive amounts of trash that enter landfills. The term green manufacturing is also used to describe sustainable energy generation technologies such as photovoltaics, wind turbines, bioreactors, Biofiltration, Bioremediation, Desalination etc. Atlas and Florida (1998) asserts that GM involves efficient production processes that encompasses source reduction, recycling and Green design.

SIGNIFICANCE OF GREEN MANUFACTURING

Zhang et al. (1997) asserts that it is important that to design function, tools and methodologies incorporates assessment of environmental consequences in each phase of products lifecycle design from the drawing room to disposal. Liu et al. (2005) urges that Sustainable development has become the key policy by which environmental control and resource usage can be done, despite continuous development. Rivera-Becerra and Lin (1999) advocated for Life Cycle Analysis (LCA) of products and services in industrial products design. LCA is described as a process for assessing and evaluating the environmental and resource-related consequences of a product throughout its life cycle (Zhang et al.1997). The other GM design element is the Green design or design for the environment (DfE). According to Sarkis et al. (2002), DfE is a set of guidelines to help designers to meet particular design goals. It is a systematic consideration of design performance with respect to environmental objectives over the full product and process life cycle. Green concept in design involves resource saving, utilise Green process, selection of proper tools and equipment, minimize the number of components, vendor selection and keeping resource use and waste to a minimum etc. Sroufe et al. (2000) examines the factors affecting DfE, and the role played by DfE tools and metrics within the new product design process. Green design and manufacturing should be based on manufacturing for reuse, design for disassembly etc. The benefits of Green design include safer and cleaner factories, worker protection, reduced future costs for disposal, reduced environmental and health risks, improved product quality at lower cost, better public image, and higher productivity. According to Schiavone et al. (2008) systematic integration of eco-design is proving to be feasible, whereas Stevels (2001) describe Green design as one way to make money in which company, customer and societal benefits are taken into account. Thus LCA usually facilitates the systematic collection, analysis and presentation of environmentally related data. The scope of LCA involves tracking all material and energy flows of a product from the retrieval of its raw materials out of the environment to the disposal of the product back into the environment.

Global increase in industrial activities led to the global problem of adverse environmental impact. To protect the world, it is necessary to adopt a preventive approach to environmental problems. Green manufacturing (GM) is the only evident solution for today's manufacturing scenario if we are to protect our environment.

Secondly, Environmental Management (EM) is such a vital field of study today. It is a profession employing huge percentage of the global population. Presently, manufacturers consider environmental management as an integral part of economic development and a need for remaining competitive in business. Also, Seliger et al. (2008) advocates that GM, its use, Green treatment and resource recovery are currently very important issues for governments and industries worldwide.

Thirdly, Greening Technical Vocational Education and Training (G-TVET) is receiving such a global advocacy as a tool for re-directing the entrepreneurial philosophy of students / trainees of production/manufacturing as a sustainable means for climate change conservation.

OBJECTIVES OF GREEN MANUFACTURING

The main aim of the green manufacturing is reduction of carbon footprint in manufacturing to save the environment and to reduce the cost of products. The specific objectives to achieving this aim is through strategies of raw material substitution, source and inventory reduction, product innovation, and closed loop manufacturing. Sustainable strategy involves planning to reduce a company's environmental carbon footprint. This implies us-

ing resources efficiently and effectively, categorization, optimizing raw material use, and energy saving. Also by applying statistical approach to GM, businesses can position themselves to develop distinguish GM strategies that integrates environmental thinking into product and process design, new product development, material selection etc. GM requires a systems level approach that starts with a strategic plan, which identifies goals, sets targets, and monitors progress of product manufacturing.

GREEN CUSTOMERISM

Green consumption is closely related to the notions of sustainable development or sustainable consumer behavior. It is a form of consumption that is compatible with the safeguard of the environment for the present and for the next generation. It is a concept which ascribes to consumers responsibility or co-responsibility of addressing environmental problems through adoption of environmentally friendly behaviours such as the use of organic products, clean and renewable energy and the research of goods produced by companies with almost zero climate or environment impact (Wikipedia.org/wiki/green consumption).

As a result of these pressures companies according to Rehman and Shrivastava (2013) GM technologies support customers in reducing their environmental footprint and help them to be more profitable in a sustainable way. These technologies include variety of practices involved in reduction of material waste, including recycling, substitution of less hazardous alternatives, consumption of waste internally, and remanufacturing. Research dealing with GM from operational technologies perspective includes themes such as reducing or eliminating use of hazardous substance, unwanted by-products, non-value added activities etc. From the literature review it is found that more emphasis is given on minimizing environmental impact by reducing, reusing, remanufacturing and recycling technologies including source reduction, minimization of resource consumption, enhancing use intensity. Resource reduction involving the conservation of energy, reduction of packaging approaches such as Green design, supply chain (GSC), investment recovery, sales and purchasing, etc are more focused.

SOCIAL DIALOGUE AND PARTNERING FOR GREEN MANUFACTURING

Social dialogue and social partnering will promote a stronger interaction among governments, workers and employers' organizations in an increasingly challenging area for the world of work: environment, green economy and sustainable development. For there to be a transition towards a green economy, there must be a social dialogue interface platforms for continues discuss on on environmental awareness, ways of improving, and implementation of policies on green manufacturing which translates to a sustainable green economy. Such a platform cover a wide range of experiences in which social partners, civil society and governments have established efficient and effective formal and informal dialogue mechanisms for addressing environmental issues, such as consultations, negotiations, or exchanges of information. A global input to creation of such a platform is such as offered by the International Labour Organisation Conference on social dialogue for sustainable development. The report of the conference stresses the need for a broad participation in environmental discussions. Different experiences described in this report thus highlight the contribution of the civil society, the collaboration between governments and international agencies, as well as regional practices of social dialogue. (ILO,2012)

STRATEGIES FOR IMPLEMENTATION OF GREEN MANUFACTURING

According to Rustina et al (2004) the implementation of these strategies can be considered under the following categorizations.

a) Production Process

Production process here involves the product design and process design. Both plays vital role in implementing Green Manufacturing. Manufacturers have to develop greener product design. This means that manufacturers have to consider the life cycle of the product and also the virgin material used. To reduce waste, biodegradable and recyclable materials should be used. Materials must also be non-toxic. Besides that, product must be designed for disassembly and remanufacturing.

This means modular product design and snap fit or push fit instead of glue and screws. In the process design, manufacturers have to move from the traditional end-of-pipe control to new technologies such as pollution prevention, production process modernization and materials substitution. Process optimization should be implemented to minimize losses and wastes in energy and materials throughout the production process .Virgin materials can be recycled

through the process of distillation and filtering. The distilled or filtered materials could be reintroduced in the life cycle wherever new materials aren't required. Waste will be reduced on the spot. Manufacturers must also improve the end-of-life management of the products. Some of the choices are repair, refurbishment and reuse; remanufacturing; recycle with disassembly; recycle without disassembly; and disposal to landfill.

b) International Organization for Standardization

The ISO 14000 environmental management standards exist to help organizations minimize how their operations negatively affect the environment (cause adverse changes to air, water, or land), comply with applicable laws, regulations, and other environmentally oriented requirements, and continually improve on the above. ISO14000 is similar to ISO 9000 quality management in that both pertain to the process (the comprehensive outcome of how a product is produced) rather than to the product itself. The overall idea is to establish an organized approach to systematically reduce the impact of the environmental aspects which an organization can control. Effective tools for the analysis of environmental aspects of an organization and for the generation of options for improvement are provided by the concept of Cleaner Production. ISO 14001 is an internationally accepted specification for an environmental management system (EMS). It specifies requirements for establishing an environmental policy, determining environmental aspects and impacts of products/ activities /services, planning environmental objectives and measurable targets, implementation and operation of programs to meet objectives and targets, checking and corrective action, and management review.

c) Regulations

There already exist some regulatory bodies individual companies inputs on green production around the globe. Some of which are according to information sourced from Rehman and Shrivastava (2013):

- *European Union (EU)*: directives issues to member states with regard to GM. Each EU member state will adopt its own enforcement and implementation policies using the directive as a guide. According to Gutowski (2002) EU focuses on product EOL, DfE, elimination of toxic, implementation of directives like waste electrical and electronic equipment (WEEE), end of life vehicle (ELV) and takes back legislation.
- *Germany*: it is the country where the 'Green movement' started; Germany has imposed the strictest European standards on its industry. Germany already imposes drives like Green taxes, eco-labeling advocates Fisher (1997). German environmental legislation is considered to be the most stringent in the world and emphasises the use of best-available technologies for the environment. The Principle of Anticipatory Protection looks toward anticipating and preventing the development of future environmental problems advocates Klassen and Angell (1998), also environmental investment positively impinges upon production growth as a productivity driver claims Böhringer et al. (2008).
- *USA*: factories practicing various GM philosophies very fast from reducing energy Use and recycling water to implementing ISO 14001 and reusing packaging, claims Brown (2009).
- *Japan*: Allen et al. (2002) states that Japan strongly emphasizes on recycling along with ISO 14000. Focus on developing lead free solder and other similar applications. The other focus is on restrictions of hazardous substances (RoHS), hybrid cars, purchasing guideline for the entire government agency. DfE is strongly correlated to a culturally ingrained sense of avoiding waste and conserving limited resources. Lack of space is a key motivator in Japan advocates Gutowski (2002).
- *China*: they are having RoHS like law (information electronic production pollution control and management), WEEE directives (under preparation), GSCM for automotive industries are going on claims Hicks and Dietmar (2007).
- *Hong Kong*: along with GM and purchasing, it prepared for implementing Green concept in design, RoHS, production management, packing materials disposal (<http://www.gen.gr.jp>, <http://www.gmn.hkpc.org>, <http://www.gpn.jp>).
- *India*: major industries focusing on reducing energy consumption, water Consumption, hazardous substances, waste, emission claims Ramakrishnan (2006). Green purchasing network is also spreading its wings in India. According to Mukherjee and Kathuria (2006) efforts are taken by leading firms for Prevention of potential hazards to the environment as well as getting ISO

14001 certification. Few of the manufacturing firms had ensured to comply with the RoHS directive.

- *Apple*: Apple is also trying to optimise the energy efficiency of their hardware tools.

It also includes take-back programs, they have launched programs in the USA, Canada, Japan, and throughout Europe, diverting over 34 million pounds of electronic equipment from landfills worldwide (<http://www.apple.com/about/environment/design/case study/powermac7200html>, <http://www.apple.com/environment>).

- *Samsung*: it plans to reduce Greenhouse gas emissions from manufacturing facilities by half within five years and those from products by 84 million tons. It will also invest US\$4.35 billion in eco-management initiatives and enhance Green partnerships with suppliers and partners within the period. All Samsung vendor facilities too need to be ISO 14000 compliant. The company's audit team audits the vendor facilities for environmental compliance.

- *Ford*: Ford has designed a car expressly for European take back. In 2009, Ford will double the number and volume of hybrids, with the new Ford Escape Hybrid rated by the environmental protection agency (EPA) as the most fuel-efficient SUV in the world (<http://ford.Digital snippets.Com/2008/12/02/ford%E2%80%99s-greencommitment/>). e.t.c

GREENING TVET (EDUCATION FOR SUSTAINABLE DEVELOPMENT) FOR GREEN MANUFACTURING

Lots of effort and fund has been sunk into the climate change issues. Yet the struggle continues for its global acceptance. Global conference, workshops, books, journals and social campaign are all aimed to bring the issue of climate change reality to the front burner of global discuss. Why are several nations still finding it difficult to accept the reality of climate change?

Well, several approaches has been adopted for climate change adaptation and mitigation. Recently, Greening technical vocational education and training (G-TVET) is considered as a better education for sustainable development (ESD). Greening TVET will not be an easy process either, greening strategies need to consider the conflicts that may arise, because green innovations will disrupt existing work processes and global economic interests . Political institutions regulates social and economic institutions hence there will be definitely global conflict of economic interest. Global economies that suppliers or users of fossil fuels seem to have trouble in swallowing the bitter pills of climate change reality. But even nations that have acknowledged such reality, there are still the issues of how to either tinker the existing structures of technical vocational education and training or develop a new curriculum separately for greening TVET. There could be a variety of challenges; the common denominators are the issues of lack of adequate trainers, curriculum development and funding. While the other two may be solved by individual /global funding supports, the issue of curriculum development isn't easy. Greening curriculum development that is sustainable must partner with manufacturing companies in integrating greening TVET all stages of their product design. But design is innovation, it is dynamic and systemic and perpetually subject to change, so the designers of greening TVET must be ready for these changes. For climate change adaptation and mitigation to be successfully sustainable, green economy is the way. The United Nations Environmental Programme (UNEP) defined Green Economy as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy is low carbon, resource efficient and socially inclusive . The basic objective of green economy is to reduce environmental risks and ecological scarcities which aims at sustainable development without degrading the environment (Durham, 2002). Green economy provides green collar jobs; The term "green-collar jobs" describes the growing number of jobs focused on sustainable products or services: electricians installing energy-efficient lights, technicians and manufacturers making wind turbines, construction crews with caulk guns (Alan et al., 2009) . For green manufacturing to be sustainable ,then greening TVET is the way to go.

GLOBAL CHALLENGES OF GREEN MANUFACTURING

a) Long Term Effort

In realizing Green Manufacturing, it requires a lot of determination from the manufacturer. Green Manufacturing is not just a short term effort as results will not show in a short period. Essential and proper education and training must

be provided to ensure the success of Green Manufacturing.

b) Investment

Companies must invest a large amount of cash in water treatment, waste treatment and emission control. As these field increases production cost, setting a higher allocation for them might result in a lower profit margin. Green Manufacturing also requires expenditure in testing, capital equipment and certification of ISO 140001.

c) Increase in Production Cost

With all the spending in the above mentioned field, there will surely be an increase in production cost. Besides that, since green material is not widely accepted yet by the industry, there will be less choice to choose from and few suppliers. This results to higher material cost which consequently increases the production cost.

d) Engineers

The real challenge is posed to the engineers. They have to weigh between product reliability and disassembly/assembly during the designing of the product. Besides that, they have to figure out methods to increase component by two times to improve its life cycle. Engineers will experience a tight process management under the Green Manufacturing policy and have to monitor the supply chain. Engineers will not only bear the responsibility given by their company but the social responsibility as well.

CONCLUSIONS

In conclusion, regarding the issues of climate change, it is vital for politics to listen to the voice of science, but there remains a significant gap between the two fields. Politicians need all necessary knowledge, but policy usually requests more than science can provide. This provokes questions about the suitability of science for political decision-making, but it is clear that science is crucial for data development and from data decisions are made. The present issues could not be addressed without scientific and technological knowledge. The world must know that Legislation, litigation, global and national campaigns are not sufficient to proffer a lasting solution to the issue of climate change. Localized Structured Greening TVET curriculum development for formal Education for sustainable development(ESD) may give a more lasting solution. Climate change is no more an illusion called up by the roguish imagination of the political class or civil society gladiators. Climate change is here with us.

SUGGESTIONS FOR MITIGATION OF CLIMATE CHANGE THROUGH GREEN MANUFACTURING

By harnessing the potential of clean technologies and promoting technology transfer will bring about significant contribution towards developing climate resilient industry.

There is a need of new manufacturing process i.e. Green Manufacturing which is suitable a sustainable development strategy. It is finally important to suggest for the need for global and national Development Greening TVET curriculum for education and training Green manufacturing and for green jobs; development of learning/instructional materials, development of cooperation networks between companies, state institutions and vocational research institutions in integrating green manufacturing concepts in both education and production activities.

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