Achieving Sustainable Development, Exclusively Through the Use of Green Technologies

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Abstract- ***Green technologies, which are also known as clean technologies, refer to the development and extension of processes, practices, and applications that improve or replace the existing technologies facilitating society to meet their own needs while substantially decreasing the impact of human on the planet, and reducing environmental risks and ecological scarcities. In recent years, climatic changes, global warming, energy depletion and other environment-related concerns have led to the emergence of green technologies. Researchers believe that the increase in the level of sustainable development will result in sustainable economics and societies. Human activities are wreaking havoc on the environment at a rate of knots and if left unchecked could result in environmental degradation beyond repair. Green technologies become vital owing to human rash usage of modern technology which in turn adversely affect land, water bodies, the lower and upper atmosphere. Green technologies are important to protect human lives, our local environment and its biodiversity for future generations. Both environmental and economic impact and efficiency of technology should analyze before the implementation of the technology in question. It should be a win-win situation when economic and sustainable growths are highly emphasized. This research contains a review of works of literature, examples and findings of researchers which posits that sustainable development can be achieved exclusively through green technologies.***

Indexed Terms- ***Green technologies, sustainable development, renewable energy, solid waste, environmental remediation and environmental impacts.***

I. INTRODUCTION

Sustainable development is a way of organizing society so that it can exist in the long term. This means taking into account both the imperatives present and those of the future, such as the preservation of the environment and natural resources or social and economic equity. It also entails the idea that human societies must live and meet their needs without compromising the ability of future generations to meet their own needs. However, achieving sustainable development goals solely through the use of green technologies is questionable since there are other factors that could contribute immensely towards achieving sustainable development. Nonetheless, my opinion is to exclusively point out how sustainable development can be maintained through the use of stringent green technologies.

Green Technology (GT) is a broad term and a field of new innovative ways to make environmentally friendly changes in daily life. It is created and used in a way that conserves natural resources and the environment. It is meant as an alternative source of technology that reduces fossil fuels and demonstrates less damage to the human, animal, and plant health, as well as damage to the world. The use of green technology is supposed to reduce the amount of waste and pollution that are created during production and consumption.

Economic development is closely linked with the energy development. Most of the world's commercial energy supplies are provided by fossil fuels, with the associated emissions causing global environmental problems [34]. It is feared that not only these levels of energy production and use from current energy sources are difficult to achieve but also unsustainable. Therefore, energy use efficiency needs to be increased to moderate the growth of energy while the contribution from clean energy sources needs to be

increased to reduce adverse environmental impacts of energy usage [6]. Green energy offers a promising alternative to traditional energy sources. The fact that renewable energy accounts for only a modest proportion in meeting the world's (commercial) energy demand means that there is a missing link in their potential and their implementation - the barriers in their implementation [11]. These barriers (either financial or non-financial) need to be identified and addressed in order to design innovative policy approaches for the international and domestic financing or renewable energy technologies [7]. Renewable energy can play an important role in helping to meet basic energy needs through the use of modern technologies Green technologies [3]. The Rio Declaration adopted at United Nations conference on Environment and Development in Rio emphasizes entitlement of healthy and productive human life in harmony with integration of environment protection in the development process. The Earth Summit at Rio adopted Agenda 21 on June 14, 1992, which proposes various actions to be implemented from now and into the 21st century to accelerate sustainable development [5]. The green technology policy to provide direction and motivation to continuously enjoy good quality and a healthy environment should be based on four pillars [15]:

- Energy: Seek to attain energy independence and promote efficient utilization.
- Environment: Conserve and minimize the impact on the environment.
- Economy: Enhance the national economic development through the use of green technology.
- Social: Improve the quality of life for all.

1.1 Sustainable Development

The World Commission on the Environment and Development also known as the Brundtland Commission, in their report, “Our Common Future” introduced and defined the term sustainable development as the process in which the exploitation of natural resources, the allocation of investments, and the process of technological development and organizational change are in harmony with each other for both current and future generations. Based on this context, “sustainability” is considered as a path forward that allows humanity to meet current environmental and human health, economic, and societal needs without compromising the progress and success of future generations [36]. Some of the definitions of sustainable development illustrating the variety of foci are:

- Development that meets the needs of the present without compromising the ability of future generations? To meet their own needs “The World Commission on Environment and Development, Our Common Future.
- “Improves the quality of human life while living within the carrying capacity of supporting ecosystems," International Union for the Conservation of Nature and Natural Resources (lUCN), World Conservation Union, United Nations Environment Programme (UNEP), and worldwide fund for Nature (WWF), Caring for the Earth.

1.2 Criteria for Selection of Green Technologies

The Green technology is the knowledge for conserving natural environment and resources and reducing human involvement. It can operate in diversified areas such as bio-fuel, eco-forestry, renewable energy, and solid waste management [28]. However, it is neither viable nor required to adopt all the available technologies at one time without considering country-specific strengths and weaknesses. The selection of tools and techniques as an appropriate technology is an important element in helping communities to decide what their future should be like. In other words, appropriate technology's search for those technologies that have beneficial effects on income distribution, human development, environmental quality, and the distribution of political power [23]. In general, the seven criteria have been proposed to judge the appropriateness of technology by Robert (1998) in his paper entitled, “Design Criteria for Sustainable Development in Appropriate Technology: Technology as if People Matter” [33].

- System Independence: It is the ability of the technological device to stand alone for doing the required job. Whether the technology will require relatively more capital or labour should be analysed to check system independence of the technology [32].
- Image of Modernity: People should perceive themselves as modern by adopting the technology. The message is people’s realization that

technological device can elevate the user's social status as well as need a basic human need. Image of modernity requires that the social status of people who adopt it either increases or remains unchanged.

- Individual Technology vs. Collective Technology: It is the criteria to look into the societal/cultural standards in which the technology operates. In other words, it is the careful assessment of the technology that is based on group approach and becomes more systems dependent. A society geared towards individual or single-family unit will need more systems independent technology. Collective technologies are more easily adopted as collective action reduces a transaction cost [19].
- Cost of Technology: Affordability of the technology is an important indicator for their wider use since cost is the major factor in encouraging or discouraging the application of appropriate technology in developing economies.
- Risk Factor: It is an important factor to find out how smoothly technology works in the local production system and system that explains to what degree is the technology system dependent or system independent. This indicates the need for understanding two types of risk- both the internal and external risk. Although analysis of risk is necessary before applying new technology, it is almost impossible to remove all risks.
- Evolutionary Capacity of Technology: If the chosen device is static, it will relatively reflect the short-lived solutions to a much larger problem. The technology, which supports the continuation of development by enhancing capability to expand, can be expected to compete at the regional, national and international level.
- Single-Purpose and Multi-Purpose Technology: In contrast to single purpose technology, multipurpose technologies are the ones that furnish a variety of applications [33].

II. FEASIBLE GREEN TECHNOLOGIES

Some of the selected renewable-energy (feasible Green Technologies) are: Solar Photovoltaic: Solar photovoltaic technology converts sunlight into electricity using semiconductor modules. Used generally for meeting lighting requirements they can also be used for pumping water, refrigeration, communication, and charging batteries. Solar photovoltaic has application as the green agricultural energy source for pumping water, street lighting in villages, lighting in rural houses and pest management. Since the technology efficiently produces low-cost, high-power photovoltaic cells, this new generation of solar energy can be one of the most affordable and efficient energy sources in the future., Wind Energy: Wind energy is in a boom cycle. Its importance is increasing in the sense that comparatively with other sources; the wind energy produces fewer air pollutants or greenhouse gases. Wind turbine for electricity or mechanical power generation is a proven technology. Wind turbines used in pumping water for irrigation can increase agricultural growth without carbon emission., Bio-fuel: Bio-fuel as bio-ethanol and bio diesel has the potential to assume an important portfolio in the future energy platter. Caution is mandatory in evaluating bio-fuel as green technology. Food security concerns and risks to environment and bio diversity are parameters that is need to be accessed while analyzing its sustainability., Biogas: Bio gas is the product of anaerobic digestion of organic matters by methanogenic bacteria. Bio gas qualifies on the merits that this technology utilizes organic agricultural waste and converts it to fuel and fertilizer. Direct impacts of bio gas are fuel-wood, agriculture residue, livestock manure, and kerosene savings. Increases in soil fertility and crop production have also been observed. Bio gas also solves the problem of indoor air pollution and improves household or communal sanitation., other forms of green technology include: Hydropower, Biomass, Geothermal Energy etc.

2.1 Review of Green Technologies

This section provides an overview of the application areas of green technologies where they have been implemented successfully.

- *Water Treatment:* Water is an essential element in life. In our world, several regions suffer from water contamination and scarcity. Water treatment is the act of removing undesirable contaminants from water. Undesirable substances may include biological, chemicals and even physical pollutants making it viable to be used in other applications. Water treatment is the solution preferred by many developing countries to reduce water stress. This

solution may be focused on different perspectives depending on applications such as industrial and human activity [12].

- *Stages of water treatment*: Today, the most common methods of water treatment include coagulation and flocculation, sedimentation, filtration, and disinfection (Figure 1).

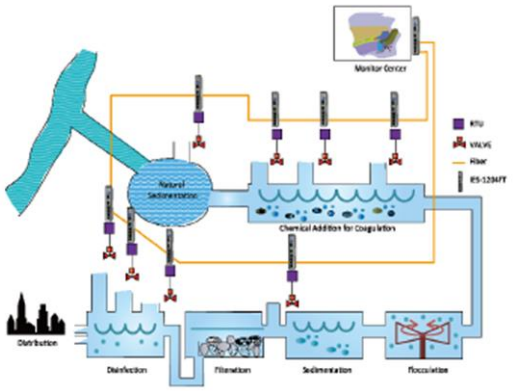

Figure 1. Basic model of water treatment scheme.

Coagulation and flocculation in most cases are often the first steps in water treatment. During this stage, a chemical with a positive charge is added to the water and the negative charge is attached to the dirt. This process detaches foreign proteins from water that form large particles called Floc [2]. Those large particles are then removed through sedimentation. The filters trap small particles that escape in the filtration stage. With current green technologies being implemented in water treatment process, most water treatment plants use advanced filtering systems such as Nano filters and membrane filters [8,14]. These filters trap minute particles [20].

The last stage is disinfection. The step removes biological organisms such as parasites, bacteria, viruses, and protozoa [2]. In the modern treatment plants, the commonly available disinfectants are chlorine and chlorimide. However, this method has proven to cause a carcinogenic effect. Thus, Ozonating is a process that is being encompassed by many developing countries [8]. The WHO is laying out regulatory laws almost every year. In 2005, it was estimated that around 94% of the diarrhea cases reported could have been reduced by treating water for consumption [8]. The remedy was to use green technologies such as chlorination, safe can storage, filtration and solar treatment. Such a sustainability of water has been achieved in many countries [6,14,20].

- *Sewerage Treatment:* This section portrays technology advancements at present that bring sustainable wastewater treatments. Wastewater treatment can be termed as the process of removing solids, organics, and nutrients from the effluents of households and businesses. The knowledge of the sewerage treatment has evolved from early centuries. In the modern society, green technologies have been encompassed in this field to help removing physical, biological and chemical contaminants from the effluents to make them eco-friendly [20]. Wastewater treatment has a significance in that it allows the water from the industries to be treated before being discharged back to the environment [12,2]. It is believed that the wastewater contains harmful compounds that will not only interfere with the quality of the environment but have adverse human health complications [18,35]. While designing a wastewater treatment plant, the following factors are put into consideration [8]:
- Remove organic and biodegradable materials
- Extract the part that is solid
- Get rid of pathogenic microbes

Wastewater primarily occurs in four stages: screening, primary treatment, secondary treatment, and final treatment.

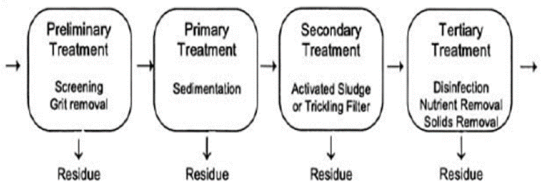

Figure 2. Common steps involved in wastewater treatment

Screening is the first stage of wastewater treatment. It removes large solids and objects from wastewaters. The primary steps separate the organic part of the waste through sedimentation tanks where they sink and settle into the ground. The effluent that leaves the main treatment contains high levels of Biochemical Oxygen Demand. Thus, secondary treatment proceeds to break down the organic matter using biological

processes [1]. Wastewater contains a numerous number of nutrients. The final stage reduces the level of nutrients before discharging the wastewater into the rivers [35].

Eutrophication is one of the adverse effects that leads to environmental degradation. The growth of plants in the water affects the level of oxygen and carbon dioxide in the water causing the death of the aquatic animals [2]. The increasing level of environmental awareness has led to various industries and homesteads to deploy green technology techniques for reusability of wastewater [2,16]. The regulatory rules set by the government and environment conservative bodies force the industry to seek technologies that minimize wastewater being produced and ensure recycling [18].

Green technologies have ensured that the wastewater produced by the industry and homesteads can be used in other areas such as irrigation and livestock watering in arid and semi-arid areas after the treatment [10]. As manufacturing industries are being designed, many have found the importance of creating a recycling plant within the same plant to cut on the cost of wastewater management [1,14]. The final water effluent may be reused in the manufacturing process. The consensus is that it is easier to treat wastewater than to formulate new plans for obtaining fresh water from underground sources [35].

- *Solid Waste Treatment and Management:* Solid waste is one of the major aspects of sustainability that has been focused in the recent past [13,22]. The government-support, for solid waste management schemes have resulted in the creation of innovative technologies that reduces waste generation [35,31]. In accordance with Product Stewardship Bill 2011 of Australia [4], there is an urge for every business to maintain responsibility and keep the environment free from hazardous waste. These regulations and codes played a pivotal role in economic and social development sustainability [13,21]. The waste disposals into the landfills go against sustainable development. The guidelines for a sustainable development are designed to cover six steps as shown in Figure 3 below, *i.e.*, Reduce, Reuse, Recycle, Recover, Incinerate and Landfill [35]. Disposing waste into landfills goes against the principles and means that new products will be processed from scratch. The end results are that there will be an increase in the demand for fuel, energy and other resources. Also, as the waste breaks into these landfills, the production of GHG emissions such as carbon dioxide and methane increases [25,27]. The technology used in waste management differ in developing and developed countries, rural to urban areas, and residential to industrial zones [12,31].

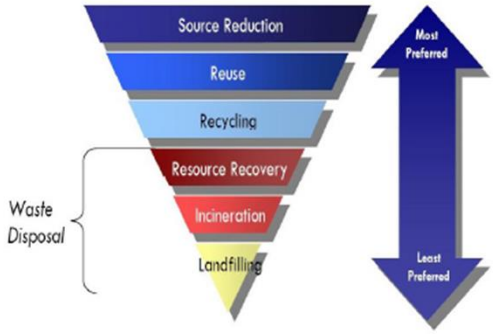

Figure 3. Solid waste management hierarchy

The old technologies adopted by waste recovery industries saw the waste disposed of in the landfill's compost to form fertilizers. However, the latest green innovations have led to the development of aerobic digesters such as bioreactors that encompass in-vessel treatment of waste [31]. The new advancements in technologies not only does it manage waste but act as a source of renewable energy. Other waste management includes gasification and plasma synthesis, and zero waste programs [26].

- *Air Purification:* Air pollution is largely becoming a technical issue. Air pollution is the introduction of harmful chemicals and GHGs into the air. They result in human and animal diseases and end results are a damage to the atmosphere [20,25]. Air pollution is believed to be because of human struggle to achieve development. The common pollutants are industries and transportation devices. Various gasses such as sulfur dioxide, nitric oxide, carbon monoxide and more toxic gasses are emitted in large amounts. Air pollution has become an escalating factor after the GHGs have led the depletion of the Ozone layer [2]. Air

filtration using green technologies has been encouraged in most industries. Most of the companies reduce air pollution by filtering GHGs during the emission process [27]. An example of technologies to reduce air pollution includes lead-free fuel and the introduction of catalytic converters. The introduction of such green technologies to trucks, buses and small vehicles will lead to significant reduction of air pollutants [20].

In the modern world, more fuel-efficient vehicles and hybrid electric cars have seen the reduction of air pollutants. These cars saw the reduction of gasoline intake by 50%. The technologies which have largely been implemented in most cities have seen air pollution reduction in the urban sector [8,12]. In power plant productions and industrial areas, filters in the emission chimneys have reduced gas pollution. Although no current technology has been put in place to deal with GHGs such as carbon dioxide, many industries have found a way to reuse gasses such as anaerobic bioreactors [10].

- *Environmental Remediation*: Environmental remediation is an important focus of the green technologies aimed at maintaining sustainability [21,22]. This section focuses on green technologies that aid in the treatment of waste, help in the reuse, eliminate or reduce hazardous waste from the environment [35]. Environmental remediation knowledge has been evolving since the 20th century. Environmental remediation can be termed as the removal of pollutants or other contaminants from soil and waters. These pollutants can accumulate in living organisms and result to carcinogenic effects and other toxicity. In some cases, remediation actions can be because of a regulatory requirement, after assessment of human health and overall economic conditions of the environment [18].

- *Green Building Practices:* Conventional buildings are the number one contributor of GHGs. However, this sector has focused on coming up with green buildings [9,17]. In the wake of climatic changes such as global warming, Green Building Practices (GBPs) are receiving global acceptance [8,2]. The GBPs are environmentally friendly and more economically reliable. Industries have come up with a new technology of building houses that are eco- and nature-friendly.

Green buildings generally cost 2-7% more than the normal conventional buildings regarding the capital. The difference in money can be suggested to arise from modeling and designing cost. Green technologies require a sophisticated design which is costly. The rise of capital could also be because of green materials and green technologies used in the project [9]. Even though green buildings are costly, there are economic productivities that result from GBPs. As noted earlier, green technologies are eco-friendly, have more property values, are more energy-efficient and above all, they are energy efficient [9]. The impact of green buildings on the environment and social life [18,35,9,17] is attained by:

- Efficient and efficient use of resources such as energy and water
- Minimization of waste, water and reduction in environmental degradation
- Providing occupation to employees, thus improving health and overall productivity

Sustainable Transportation: Sustainable transportation is a transport system that results in a positive impact on the environment. With current green technology being utilized in the manufacture of green vehicles, there will be less emission of GHGs compared to standard cars, thus leading to a sustainable environment [8,20]. Environment Protection Agency defines sustainable transport system as [30]:

- A transport system that allows society to quickly fulfill the urge or development at the individual level, company or even community level sustaining social-economic and environmental health
- A transport system that is efficient and supports the competitive economy and may result in economic advancement
- A sustainable system that reduces GHGs emission by utilizing a renewable source of energy and has reduced impact on a waste generation.

The introduction of electric hybrid cars leads to a reduction in carbon dioxide emitted during transport.

Capture and Storage Technology: Capture and Storage (CCS) is aimed at reducing GHGs emission. CCS captures carbon dioxide from environment and stores it in a viable surface. It follows a 3-step process as explained in Figure 4 below. The process involves capturing carbon dioxide from power plants, transporting carbon dioxide through pipes and the storage of carbon dioxide [24]. CCS technology sees carbon dioxide deposited in oil and gas recovery sites or un-mine-able coal sites.

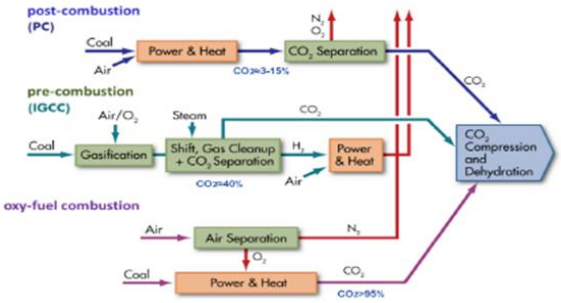

Figure 4. Summary of Carbon Dioxide Capture Technologies [25].

III. CHALLENGES FACED BY GREEN TECHNOLOGIES

Technologies have impacted our society and its environment in many ways and helped in developing more advanced economies such as today's global economy [29]. Green technologies are environment healing technologies. They minimize environmental damages brought by technologies created by humans for their conveniences [12]. However, green technologies have been facing challenges that make it harder to realize the set goals. Such challenges include marketing challenges, economies of scales, financing problems, and regulatory and technical challenges.

IV. IMPACTS OF RENEWABLE ENERGY RESOURCES

4.1 Social impacts

These resources also provide social benefits like improvement of health, according to choose of consumer, advancement in technologies, and opportunities for job, but some basic considerations should be taken for the benefit of humans, for example, climate conditions, level of education and standard of living, and region whether urban or rural from agricultural point of view. Social aspects are the basic considerations for the development of any country. The following social benefits can be achieved by renewable energy systems: local employment, better health, job opportunities, and consumer choice. The study concluded that the total emission reduction is exponentially increasing in different years after the installation of renewable energy projects in remote areas [37]

4.2 Economics

It was discovered that renewable energy projects provide benefits in economic point of view because they utilize local labor from rural areas, local material and business, local shareholders, and services of local banks. In addition, renewable energy projects would facilitate the communities by establishing a trust fund that aims to invest the money earned by selling electricity in local economy. This would make it easy for a few communities to invest money on any small business of their own choice. The consumers will be provided with electric power at a low cost as compared to that of conventional energy sources, and overall economy will be enhanced because there will be multiple options to generate power using different renewable energy sources present in that region [37].

4.3 Environmental impacts

Renewable energy projects have also contributed in improving environmental impacts such as reduction of carbon dioxide gas, awakening community about the climate change. There will be positive impacts on the standard of life, social bonds creation, and community development. The two main aspects of environment are air and water pollution, normally created by the discharged water from houses, industries, and polluted rain, and discharge of used oils and liquids which contains poisonous chemicals and heavy metals like mercury, lead, etc. Along with water pollution, natural resources can be maintained and greenhouse effect and air pollution can be mitigated by the proper usage of renewable energy sources.

4.4 Sociopolitical impacts

Solar panels are usually installed at the roofs of the buildings that increase the job opportunities in the PV system fabrication and installation. This increases the regional development and reduces the usage of energy

from nonrenewable energy projects. It is very useful at the regions where there is no access of electricity. The major problem with solar system is the high investment and maintenance cost. Biomass energy projects have great contribution in the local job creation and the development of rural areas. Such types of power plants have large opportunities of jobs in construction of plants, management, maintenance of plants, production, and preparation of biomass. Only the noise production and unpleasant smell are the negative impacts of these plants. In hydro power plants, the major sociopolitical problem is the shifting of the people from the areas where the plant is going to be constructed. These plants provide significant jobs for local community and also play an important role in the economic development of the community. The construction of tidal energy plants has no effect on humans, and they have better contribution in the local and official employment. These plants are very expensive and are not common. Wind energy projects do not have any emigration problem, and they create large number of job opportunities especially for engineers. Geo thermal energy projects provide the following sociopolitical benefits: improvement in the education of local people, improvement in living standards, and improvement in health care [37].

CONCLUSION

In conclusion, if dialogue on existing national green policies are intensified by considering the best practices such as: extending public procurement of clean technology, large-scale government purchases and deployments of green technologies, cutting taxes on green products, opening and sustaining the markets for green technologies through better trade policy, this would facilitate the expansion of the cleanest technologies and it will encourage individuals to key into the idea which will in turn lead to achieving sustainable development through the use of green technologies.

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