**Biomass energy in India and implementation challenges**

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Global energy demand in the twenty first century is currently witnessing a substantial growth of demand that is coupled with increasing energy –intensive productions to meet the ever growing needs of consumer populations. Since the first industrial revolution in 1784, Fossil fuels namely coal, oil and gas have continued to play a pivotal role in the provision of global energy demand albeit its detrimental effects towards the environment. As a global oil and gas producer, the energy sector in India is heavily dependent on conventional fossil fuel resources, where 88.4% constitutes fossil fuels and can be further broken down to account for 53.3% natural gas, 30.5% coal 2.8% fuel oil and 1.8% diesel . While the remaining are constituted by hydropower. In 2016 electricity generated by fossil fuel based thermal plants remained dominant at 83.2% compared to hydro power at 12.8% thus high lighting its continued dependency as main resource for the energy generation.

Nevertheless the current world energy development scene is transiting in to new period, where low carbon emission clean and environmental friendly characteristics have been prioritized for the generation of energy. Based on the report by the International Renewable Energy Agency (IRENA), the global renewable energy generation capacity amounted to 2.537 GW with 7.4% growth as of 2019 as compared to previous year. Refining to Tock et al selection of appropriate renewable energy in any country depends on three factors, geographical location , climate condition and avaibility of renewable resources. Thus in local context where India is blessed with tropical and humid climate for agriculture and forest plantation, biomass energy (bioenergy) utilization is formidable under lying potential that can be capitalized to develop the local renewable energy scene in India and as an option to reduce green house gases (GHG) emission by 45% of nation GDP by 2030. Unlike fossil fuel biomass production and utilization are promising due to net carbon dioxide (Co2) emission, since released co2 during power generation will be compensated by the co2 consumption in photosynthesis process . Referring to recent assessment done by the Stougie et al, environmental sustainability of the biomass energy is indeed lower as compared to coal fired power plant (12vs 19Mpt.) . Here in, bioenergy is a form of renewable energy generated from biomass sources via traditional and modern approaches where traditional technique rely on combustion of biomass to generate energy while modern technologies involve liquid biofuel production, biogas generation by anaerobic digestion or bio refineries as illustrated in Fig 1 . Furthermore, production of bioenergy is obtainable in the form of agricultural and wood processing wastes, residues and forest product such as logging residues. As the fourth largest resources around the world, the adaptation of biomass to energy sources is prospective as it is dis inactively abundant in nature and can be easily generated in non- urban settings in Indian context.

Thus the paper out lines current status of bioenergy deployment in India, specifically biodiesel fuel and valorization of biomass towards the emerging bio-ethanol and bio gas sector. The paper seeks to compare current local policies (short and long term) with respect to the countries with successful bio economy frame works implementation like Finland and Sweden as well as tropical countries with similar aspirations such as Thailand and Indonesia as bench marking study. Lastly this review paper explores the trilemma factors with respect to the pillars of sustainability for amelioration of biomass energy implementation and mitigation at the local context settings.

**INDIAN BIOMASS ENERGY, INDUSTRIAL STATUS AND DEVELOPMENT:**

The Agriculture sector is a leading contributor of biomass in India; hence it has a great prospect to be commercialized for bioenergy production. To date bioenergy particularly Jatropha has emerged as a potential sustainable and eco-fuel in India , due to its resemblance with the conventional diesel with respect to chemical structure and energy content, low sulphur content non toxicity and high biodegradability as well as good combustion efficiency. On top of that Indian Jatropha biodiesel for transportation has been accepted by the Automobile Manufacture Association

**CHALLENGES OF BIOMASS ENERGY IMPLEMENTATION AND MITIGATION PERSPECTIVE:**

Regardless of numerous advantages on the biomass energy, abundance of the biomass sources in the country, along with the multiple initiatives by the government and respective agencies there are several challenges for its implementation in a large scale. These challenges can be grouped in to several categories, including technical financial, economic, social environmental impact sustainability and lacking in institutional/ organizational issues.

Basically slow evolution of biomass energy in India can be attributed to the technical challenges in corporating the technological barrier as well as un availability in technical experts. Due to an absence in local advanced technologies most of the techniques have been imported from the foreign countries as such this implies high production and maintence cost. For instance, it has been reported that the technologies for biogas production in India through the anaerobic digestion technique have been imported from the Germany. Moreover, lacking in the scientific and technical local expertise particularly related to technology design and construction as well as operation and maintence of the biomass power plant explains the low penetration of biomass energy in India. Here limitation in local expertise is plausibly due to the lack of technological courses on bioenergy in the higher institutions. It is therefore imperative for the collaborative work between the Government and educational institutions to provide skill and work force training as well as knowledge inputs to skilled personnel and human resources. Besides joint development opportunities between the countries are a good way for sharing the expertise and towards the development of bioenergy technologies accordingly, can transform India as a bio economyhub in the Asian region . Another technical barrier that is freed in the bio energy deployment in India is interrelated to infrastructural barriers. Ideally, distance between the renewable energy plant and the interconnection point of the distribution system needs to be with in 10 km distance to prevent the power loss.

The financial (or economic) barrier is amongst the common challenge faced in fastering the biomass energy in India. Basically, the economic barrier includes several criteria including the high capital expenditure lack of experience trust amongst finances and /or investors absence in the appropriate financing scheme and competition from fossil fuel as well as fewer subsidies as compared to the conventional fuel .From the Indian Government and industry perspective high capital investment needed has been perceived as the greatest weakness for biomass utilization to energy production. India can reach up to 10 million dollars which causes burdens to the developers due to long pack period Here in such huge investment can be caused by the replacement of the conventional boilers to grid connected high presence boilers and dependency on the imported equipment ,it further added that the investment cost can escalate up to 30% can also be attributed by the change in plants location, licensing related costs and /or modification of the plant design. Based on recent survey , 100% of the respondents agreed that high capital cost borne by developers, it is more likely that the cost will be transferred to customers which consequentially results in an unattractiveness of this biomass energy.

Due to multiple benefits of bioenergy that are particularly related to climate change mitigation, improvement in energy security and rural development, it is undesirable that the biomass energy can boost up India renewable energy sector in future. Besides the bioenergy development in the country is supposed by the increasing abundance of biomass, from the analysis several insights have been drawn : first despite government efforts in promoting the bioenergy market and use via policy formulation and incentives there are still barriers that hinder the market penetration. In addition, compared to other region, carbon tax and pricings had not gained significant tract on in the Asian countries and cause dis couragement to industry players in championing the biomass related renewable energy production. Second, there are also limitation in technology in technology

and technical experts high capital expenditure, limitation, lack of knowledge and aware ness of the public and opposition and reluctance of the market developers as well as associated environmental challenges due to deforestation and green house gas emission for the manufacturing process with regard to these challenges, it is anticipated for the Indian primary stake holders in energy-related to find optimal solutions and further strengthen the bio-energy sector. Overall the review of energy in India is promising as the database provided i,e challenges for an effective implementation can serve as a guide line to the researchers and industry players in going forward and expanding the bioenergy sector further.



