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Biomass & Bio-waste Supply Chain Sustainability for Bio-energy and Bio-fuel Production

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Abstract

The terrestrial biomass feedstock can be generally categorized into two groups. The first group includes corn grain, sugarcane, soy bean, oil seed, etc. The second group of terrestrial biomass feed stocks, the cellulosic biomass, can avoid adverse impacts on food supply, because they are non-starch, non-edible and non-food feedstocks. Cellulosic biomass feed stocks can be obtained from a number of sources, such as agricultural residues, forest residues and energy crops. Currently, most bio-fuels are made from these feed stocks, due to the maturity in technologies and lower unit production cost. However, the use of these feed stocks for bio-fuel production might have implications both in terms of world food prices and production. Agricultural residues are typically plant parts left in the field after harvest (e.g., corn stover), as well as the secondary residues like manure and food processing wastes. Bio-fuel policies play an important role in the development of the energy sector specifically in the developing countries. The profitability of bio energy and bio-fuel production is significantly influenced by policies affecting multiple sectors such as agriculture, research, industry and trade. Identifying relevant policies and quantifying their specific impacts is difficult given the variety of policy instruments (taxes, subsidies, price support, etc) and the way they are applied. While reviewing the literature and the implementation projects, it has been observed that one of the main challenges is to develop an efficient and robust supply chain management system for sustainable bio-energy and bio-fuel production. There are many research activities found on bio-energy and bio-fuel production but the number of implementation as a business case is scant in the developing countries including India. Present study has reviewed the biomass and bio waste supply chain for bio energy and bio fuel production and investigated the cause of the major challenges and issues in India. It also proposed some feasible solutions for the developing countries. It may be concluded that the main challenge lie on the feedstock supply, farmers' choice for traditional use of biomass, economy of scale, efficiency, export of output energy and the major issue being the government policy. The study will definitely help in implementation of bio-energy production projects and the researchers for further improvement.

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Keywords : Biomass & Bio-waste feedstock, Supply Chain, Sustainability, Economy of scale

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Introduction

The combustion of petroleum based fossils fuel has become a concern with respect to the global climate change due to increasing rates of carbon emission. Fluctuations and uncertainty in supply and cost of fossil fuels made it unreliable burning source. There is convincing evidence that oil prices may trend higher over the next two decades and this would have a substantial negative macroeconomic impact for India, China and other developing economies. A 50% increase in oil prices between 2010‑2030 would significantly reduce economic growth, real consumption and household income. Expansion of biodiesel is one policy response the countries can use to counteract the economic impacts of oil price hikes. Biodiesel intervention can significantly counteract these negative impacts whereas ethanol intervention has a minimum offsetting impact. Combining supply‑side energy solutions, like biodiesel development, together with modest energy efficiency improvements and productivity improvements in agriculture will provide impressive results[1]. These factors associated with many others made all the countries in the globe to think of alternatives to fossil fuels. Bio-energy as sustainable renewable energy option attracts many hopes associated with many challenges. Bio-energy helps in promoting rural and regional development promoting rural diversification by creating jobs and income usually in underdeveloped rural areas[2], it promotes regional improvement[3] and importantly, it helps in reducing CO2-emissions preserving non-renewable resources to enhance energy security[4]. The bio-energy and bio-fuels have been taking the gap at a faster rate by providing the supply of green energy replacing the energy from fossil fuels. US and the Brazil are the leaders of producing starch based first generation fuel from food crop sugars using conventional technologies. Energy efficiency of bio-fuels varies strongly according to plant species and feedstock, local climate, and production technique. Bio-ethanol from Brazilian sugar cane yields 8 units bio-energy output from one unit fossil fuel input into the production process based on life cycle assessment. Biodiesel produced from rapeseed in the EU has a ratio of 1:2.5, while bio-ethanol from US corn merely holds an efficiency of 1:1.5[5,6].

In India, 23% of rice straw residue produced is surplus and is either left in the field as uncollected or to a large extent open-field burnt. About 48% of this residue produced is subjected to open-field burning[7] in Thailand, and in the Philippines it is 95%. The GHG emissions contribution through open-field burning of rice straw in India, Thailand, and the Philippines are 0.05%, 0.18%, and 0.56%, and the mitigated GHG emissions when generated electricity is used would be 0.75%, 1.81%, and 4.31%, respectively, when compared to the total country GHG emissions. It is estimated that 97.19, 21.86, and 10.68 Mt of rice straw residue are produced in India, Thailand, and the Philippines, respectively. China contributes to about 30 % of the world's total rice production whereas India contributes to nearly 21%[8,9]. The other two major rice-producing countries in Asia are Thailand and the Philippines contributing 4% and 2% of the world's rice production respectively. Rice straw is one of the main field based residues produced along with this commodity and its applications vary widely in the region[10,11].

The total installed costs of biomass power generation technologies vary significantly by technology and country. The total installed costs of stoker boilers was between USD 1 880 and USD 4 260/kW in 2010, while those of circulating fluidised bed boilers were between USD 2 170 and USD 4 500/kW. Anaerobic digester power systems had capital costs between USD 2 570 and USD 6 100/kW. In India and China there are several types of technology developed at low cost. The quality and the sustainability of that technology should be assessed before the decisions are made. Indigenous developed technology should always be preferred for small sized plants for achieving business model. Gasification technologies, including fixed bed and fluidised bed solutions, had total installed capital costs of between USD 2 140 and USD 5 700/kW. Co-firing biomass at low-levels in existing thermal plants typically requires additional investments of USD 400 to USD 600/kW. Using landfill gas for power generation has capital costs of between USD 1920 and USD 2 440/kW[12]. The cost of CHP plants is significantly higher than for the electricity-only configuration. Operations and maintenance (O&M) costs can make a significant contribution to the levelised cost of electricity (LCOE) and typically account for between 9% and 20% of the LCOE for biomass power plants. It can be lower than this in the case co-firing and greater for plants with extensive fuel preparation, handling and conversion needs. Fixed O&M costs range from 2% of installed costs per year to 7% for most biomass technologies, with variable O&M costs of around USD 0.005/kWh. Secure, long-term supplies of low-cost, sustainably sourced feed stocks are critical to the economics of biomass power plants[13]. Feedstock costs can be zero for wastes which would otherwise have disposal costs or that are produced onsite at an industrial installation (e.g. black liquor at pulp and paper mills or bagasse at sugar mills). Feedstock costs may be modest where agricultural