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APPLICATIONS AND CHALLENGES OF THE PALM BIOMASS SUPPLY CHAIN IN MALAYSIA

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ABSTRACT

Nowadays, biomass is considered as one of the main sources of energy for both developed and developing countries. Biomass is one of the potential resources of renewable energy as the novel solution for consuming and depleting the fossil fuels. Utilization of biomass for bioenergy production is a beneficial alternative to meet the increasing energy demands, reduce the carbon dioxide emission, global warming and climate change. In order to deliver a competitive biomass product, it requires a robust supply chain. This paper summarized the recent literature related to optimizing the biomass supply chain in different countries. Moreover, the barriers and problems related to the palm biomass supply chain in Malaysia and review of some operational, economic and social challenges about the biomass supply chain were investigated. Finally, several recommendations are offered for future development on the relevant fields, such as cost, strategic planning, and policy implication. This study has specific importance and very few studies have been done which reviews the biomass supply chain of Malaysia.

Keywords: Palm biomass supply chain, biorefinery, fossil fuels.

INTRODUCTION

Today, global warming has become one of the crucial problems in the world. International communities are trying to reduce the greenhouse gases that accelerate the global warming [1-3]. On the other hand, development of renewable and sustainable energy resources plays a significant role in the current global policies to decrease greenhouse gases generation and especially replacing fossil fuels [4]. Biomass is a renewable and versatile energy source, which is used in combined heat and power generation and transportation system. Recently, some governments around the world such as Malaysia, U.S., Brazil, and many European countries have tried to increase the commercialization process of the biomass industry [5]. In a country that has a high amount of agricultural activities such as Malaysia, biomass can be a very potential alternative source of renewable energy [5]. After Malaysia and Indonesia are currently the world's largest producers and exporters of palm biomass. Hosseini *et al*. [5] reported that Malaysia produces about 47% of the world's supply of palm oil. In the case of Fresh Fruits Bunches (FFB), for every 1 ton of oil palm fresh fruit bunch processed, it was estimated that 230 kg of Empty Fruit Bunches (EFB) would be generated [5]. As cheap biomass resource, EFB could be important feedstock to produce various products. This move is indeed in line with the current government strategies such as the Renewable Energy Policy, the National Biomass Strategy 2020 and the 1 Malaysia Biomass Alternative Strategy, which encourages biomass utilization for value-added product production and bioenergy generation [5].

The most critical concern of companies today is the rapid delivery of products or materials of good quality at low cost [6]. One critical issue in energy supply via palm biomass is to utilize the biomass efficiently and effectively by lowering the cost of the supply chain and the process to change the biomass into a useful energy resource. The larger fraction of the cost in biomass energy generation originates from the transportation and logistics operations. There are several factors which affect the biomass efficiency such as quality, feedstock availability, transportation, handling, and stock. Therefore, the scientific communities and industrial managers are trying to design and manage the stages of biomass supply chain in an integrated and cost-effective manner [7]. The delivery of biomass to bio refinery comprises of the production process (harvesting, and pre-processing) and the logistical activities (storage, transportation, and transshipment) (Figure-1) [8]. The logistical activities consist of the link between the production and the consumption of biomass, thus adding value to the supply chain based on distance, time and place utility [8]. Integration and collaboration of the production and the logistical processes of the biomass supply chain (BSC) are critical for the competing biofuel industry.

Additionally, many supply chain models that have been developed do not integrate the entire sustainability concepts such as economic, environmental and social issues [9]. Sustainability means meeting today's energy needs for environmental stewardship, economic prosperity, and quality of life without compromising future generations' ability to meet these needs of energy for themselves [10]. The three main sustainability concepts that need to be considered are economic, environmental, and social responsibility. Firstly, the economic concept considers the profit maximization in the biomass supply chain. Secondly, the environmental sustainability considers greenhouse gas (GHG) emission for transportation or raw materials from the supply sources, pre-treatment plants, biorefinery plants, and the demand zones. Finally, sustainability from the social perspective considers maximizing of social benefits based on some threshold of investments. Biomass supply chain models that integrate sustainability provide a better

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decision making and will forecast realistic profits or costs. This will help in better coordination for the activities in the entire supply chain. An economic model which promotes environmental and social needs is crucial for economic and sustainable growth [11]. So this work aims at reviewing the literature related to optimizing the biomass supply chain in different countries as well as investigating the barriers and problems related to the palm biomass supply chain in Malaysia based on operational, economic and social challenges. Lastly, some recommendations for future development related to cost, strategic planning and policy implication are suggested.

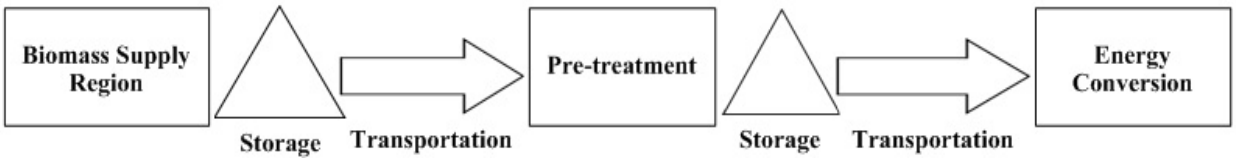

Figure-1. Operational component of a biomass supply chain [8].

LITERATURE REVIEW

The supply chain of biomass has been modeled and analyzed in literature to improve its performance in terms of biomass delivery and the total logistic cost as can be seen in Table-1. In this regard, a wide range from strategic to operational decisions have been made, such as the location and capacity of the conversion facility, location of storage sites, inventory and shipment planning, and timing of harvest. Different decision-making tools have been developed to find the solutions for these decisions. Some studies employed static methods including spreadsheets and Geographical Information Systems (GIS) based tools. A portion of the relevant studies has exploited the power of simulation modeling mainly for planning and scheduling the operations at the operational level. Another popular tool is mathematical programming that widely used to make optimal decisions at the tactical and strategic levels. For example, one optimization model by considering the biomass uncertainty was developed by Kim *et al.* [12] to determine the best biomass supply chain network design the in the South-eastern region of the United States. Hand and Murphy *et al.* [13] evaluated the transportation of four different kinds of forest biomass to energy plants by suggesting an optimization model of truck scheduling for transportation.

Based on the literature reviewing, it should be cited that these optimization models may not be conducted in the real world of biomass supply chain. Since most of these proposed optimization models concentrated on making a decision based on the tactical and strategic level of biomass supply chain. Moreover, the stochasticity and time dependency as two significant parameters were not taken into account in the proposed models to determine the optimal solutions.

Table-1. A summary of recent investigations about biomass supply chain design.

Author	Approach	Objective of Investigation
Kim et al. [12]	optimization model by considering the biomass uncertainty	To determine the best biomass supply chain network design in the South eastern region of the United States.
Hand and Murphy [13]	Optimization model of truck scheduling for transportation.	To evaluate the transportation of four different kinds of forest biomass to energy plants.
Mansoornejad [14]	multi-product, multiechelon mix integer linear programming (MILP) for forest biorefineries	To present a scenario-based strategic supply chain design technique based on applying two types of scenarios, called supply chain network and market scenarios.
Osmani and Zhang [15]	(MILP)	To optimize the overall profit while decreasing environmental effect of a lingo-cellulosic bioethanol supply chain under uncertainties.
Woo et al. [16]	(MILP)	To reduce the total cost for an extensive biomass to-hydrogen (B2H2) supply chain with inventory plans and import.
Shabani and Sowlati [17]	stochastic programming model	To incorporate uncertainty in the forest-based biomass supply chain by considering the tactical supply chain designing of a power plant and uncertainties in the quality of biomass.
Pinho et al. [18]	Discrete event simulation	To develop a dynamic simulation model of a wood biomass supply chain located in Finland.
Mitra Kami Delivand et al. [19]	Geographical Information System along with Multi-Criteria Analysis (GIS-MCA)	To deal with the logistics of biomass-to-electricity in the region of Apulia, Basilicata and Campania in Southern Italy.

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RESEARCH METHODLOGY

The methodology adopted includes searching and reviewing the recent papers that were published within 2012-2016 as well as analyzing and interpreting the findings. All appropriate papers related to biomass supply chain were searched using different criterion and were sorted according to their relevance to particular sections in this paper. Literatures were retrieved from Science Direct and Google Scholar.

RESULT AND DISCUSSION

Existing problems of palm biomass supply chain in Malaysia

Table-2 identifies the problems related to biomass supply chain in Malaysia and depicts the obstacles which are limiting biomass power generation with respect to the specific feedstock used. The risks are mainly associated with broader areas like the production of feedstock, technological barriers, a market for biomass power, economic and environmental aspect and policy regulation.

Operational, economic and social challenges

The existing sustainability issues of supply chain related to different feedstock can be broadly classified into operational, economic, social challenges. In the following Table-3, the challenges and issues and consequences related to the biomass supply chain are listed.

Table-2. Constraint and risks associated with biomass supply chain in Malaysia [20].

Biomass Resource	Barriers
Oil Palm Biomass	✓ Oil palm biomass includes substantial moisture and transporting wet biomass is energetically inconvenient and costly with increasing distance. ✓ Clearance of lands or forests for oil palm plantation is threatening some of the last habitats of endangered species. ✓ EFB needs drying to prevent biodegradation prior to pyrolysis process that enhances the production cost and equipment's investment. ✓ The Malaysian government is subsidizing 31% of the domestic fuel price which in turn makes the electricity generating cost from conventional sources lower than the power production cost from renewable fuels. ✓ Most of the existing plants have incompatible installation and not capable of generating sufficient energy for connection to the main grid. Also, lack a feasible interconnection scheme and excessive cost for a grid extension line.

Table-3. Existing challenges of the biomass supply chain.

Type	Issue	Consequences
Operational Challenges	• Feedstock unavailability [21]	✓ hinder the expansion of the biomass industry ✓ make the supply problem worse
	• Regional and seasonal availability of biomass and storage problem [21]	✓ seasonal variation of the fuel price ✓ acquisition of land for harvesting and storage is difficult ✓ unfavorable and costly transportation with increasing distance
	• Inefficiency of conversion facility and core technology and equipment shortage [22]	✓ lack of standards on bioenergy systems and equipment ✓ increases the production cost and equipment's investment
	• Lack of a feasible interconnection scheme [23]	✓ the excessive capital cost for a grid extension line
	• Immature industry chain [24]	✓ impossible to get long-term contracts for consistent feedstock supply in reasonable price ✓ low ability to gain profits
Economic Challenges	• Feedstock acquisition cost [24]	✓ scattering the biomass resources ✓ centralization of biomass projects ✓ breaking the balance between supply and demand ✓ the higher price of the feedstock
	• Limiting financing channels and high investment and capital cost [24]	✓ decentralized capital and poor profitability ✓ frequent fluctuations of international crude oil prices ✓ high market risk
Social Challenges	• Conflicting decision [25]	✓ Lack of coordination between stakeholders
	• Land use issues [25]	✓ deforestation ✓ loss of ecosystems preservation and the homes of indigenous people
	• Impact on the environment [25]	✓ threatening some of the last habitats of endangered species ✓ potential influx of labour and increased need of services, increased traffic on rural roads, changes in aesthetics and recreational value.

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Plans and strategies to promote biomass utilization for energy production

Selection of Suitable project site: Storage and transportation problem has been recognized as the main barrier of biomass supply chain whereas, on-site generation of energy can decrease the transportation and collection cost [21].

Expanding financing channels: Government should reduce investment barriers and finance the biomass industry from the capital market at home and abroad [24].

Improvement of technology and proper resource utilization: suitable research and development system should be developed for grasping core technology and avoid the import of equipment [26].

Construction of a mature industrial chain: A mature industry chain is essential, that includes raw material purchase, storage, transportation, generation, selling and waste processing. It is important to have a clear understanding between the different stakeholders associated with biomass project. Direct purchasing pattern where farmers and plant owners do the feedstock transaction directly can reduce the feedstock cost due to the elimination of third party brokers and this will help to stabilize the feedstock supply imbalances. Also in order to establish a stable mechanism for power selling, the enterprises need more communication with downstream firms [24].

Community participation, development of relative policies and strengthen support: Promotional campaigns about the benefits of renewable energy programs can influence the decision of different agency about participation and investment in the industry. The government can also exploit media and the internet to deliver information which will reach to wider audience. The government should include a carbon tax for conventional power generation, transfer some of the conventional energy subsidies, differentiate the tariff level by considering the location and local conditions of the plant site to promote the renewable market and imposing a levy for exporting fossil fuels [21].

CONCLUSIONS

Biomass plays a leading role as a renewable energy source for improving the economic, environment and energy safety. Biomass energy has illustrated less environmental effects compared to the current non-renewable energy production. It has been proven that not only biomass has great potential to supply energy in a cost-effective and sustainable manner but also GHG reduction targets could be obtained using the biomass energy. Despite the benefits of using biomass, technical and economic challenges hinder its intensified use. Biomass is scattered over large regions that enhance the collection, handling, and transportation costs and limit the competitiveness of biomass against other energy sources. Therefore, there is an essential need to assess, design and schedule the biomass supply chain to meet all the requirements to have an efficient biomass supply chain. Various methods and approaches have been used to optimize and improve the biomass supply chain stages such as transportation, facilities, storage. Biomass energy is involving many research fields particularly concentrate on the biomass production technologies such as size, location, and production facilities. So in this paper, firstly, some recent literature about the biomass supply chain optimization in different countries were reviewed. Following that, the existing problems of BSC in Malaysia were investigated. Moreover, the operational, economic and social challenges, issues and effects related to BSC were assessed. Finally, some strategic decisions and plans that should be made by the government were suggested. Right decision making on the supply chain management is significant to install a successful bioenergy plant. All the steps of the supply chain should be taken into account from the biomass and land availability to the end market demand. For example, if biomass is not available in abandon then, to decrease the transportation cost, it is feasible to build two or three small bioenergy plant than to a centrally located large bioenergy plant. Additionally, improvement of the conversion technologies can decrease the production cost and increase profit. Moreover, because the lack of attention to sustainable development in BSC, researcher are expected to make more efforts to sustainability covering all the three aspects. Finally, conducting case studies of biomass supply chain network design in different countries with different climates such as Malaysia, Indonesia can be also considered as one important future research opportunity.

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