THE ECONOMICS OF BIOMASS WASTES TO BIOENERGY

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Introduction

Energy security has become a major challenge in human development in this era. Increasing energy demand, depletion of fossil resources, greenhouse gas emission and climate change bring complications to our environment and urges toward sustainable alternatives. One of the possible coping strategy is to develop renewable energy. Malaysia is blessed with tropical climate and fast-growing biomass. The biomass from crop residues can be used to generate biofuel without causing changes in land use, thus, avoiding competition with food. Many studies did show that Malaysia has good potentials to utilised biomass residues for biofuel. The estimated available biomass in Malaysia from agricultural and forest residues is up to 45.78 million dry tonne in year 2007, equivalent to 9.2 million ton of biofuel (Goh & Tan, 2010). Although biomass is seen as valorising wastes, it does not come with no cost. Biorefineries could aspect 33 to 50 percent of total production cost just for feedstock transportation (Kumar, Sokhansanj & Flynn, 2006). Even though biomass waste has low or no market value, the underlying natures of these resources have certain constraint to bioenergy industry.

The Natures of Biomass Resources

The main factor that affects transportation cost of biomass is accessibility. The accessibility of each biomass is affected by its spatial diversity. As illustrated in Figure 1, it varies in terms of density and distribution. Depending on the location of the mill, the accessibility to the resource will differ greatly and will significantly impact the transportation cost. In each section of Figure 1, location I can access more biomass areas with less distances compare to location II. When more distances are required, the higher transportation cost would be incurred.

To evaluate the impact of biomass spatial structure, a GIS simulation was performed by computing distances of biomass from different potential biorefinery locations, using the road network within Peninsular Malaysia. The findings are illustrated in Figure 2. Each of the biomass source has its own best location. In each

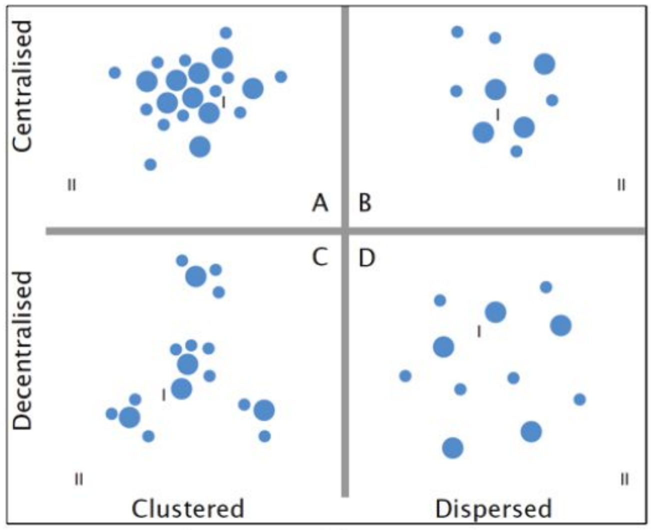

Figure 1. Spatial structure of biomass resources (Adapted from: Rodrigue, Comtois & Slack, 2013)

section, the optimal biorefinery location is able to minimise distance and maximise supply, as it requires less distance to access the biomass areas. For non-optimal biorefinery locations, more distance is required to access the same biomass areas. In Peninsular Malaysia, the forest logging residues and oil palm trunk spatial structure reflect the patterns from Figure 1A and 1B respectively. Their accessibility curves show that the areas of biomass sources follow a sigmoid shape. Rice straw structure is illustrated in Figure 1C. Its accessibility takes a staircase-liked curve. This is because areas of rice straw are clustered, with a lot of distance between the

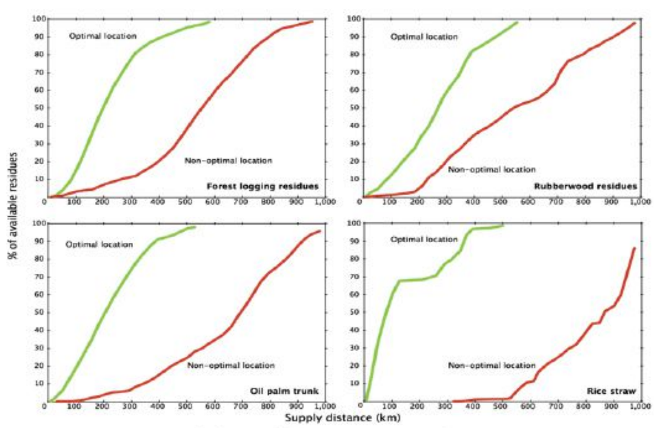

Figure 2. Accessibility of biomass residues in Peninsular Malaysia

different clusters. Rubberwood residues are geographically dispersed and are quite scattered. Thus, their accessibility graph increases steeply, suggesting that every area of rubberwood require a substantial amount of distance to reach.

A Paradigm Shift on Productivity

In conventional economic theory, when one increases the quantity produced, its marginal cost will diminish due to increased productivity. As shown in Figure 3, the unit cost decreases as the quantity increases up to its optimal point due to the scale effect. Unlike conventional economy of scale, the biorefinery is influenced by the nature of biomass resources. When the biorefinery increases its scale, the input required increases and more distances and cost would be incurred to acquire the biomass feedstock. Thus, the location of the mill is pivotal to the biorefinery's feasibility and sustainability, because it is the key to optimise the feedstock supplies and cost.

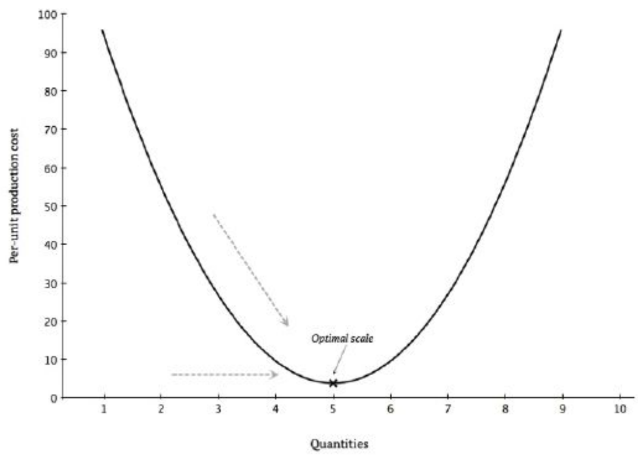

Figure 3. Conventional economy of scale

The following figures show the estimated unit production cost for biorefinery in Peninsular Malaysia, in the case of oil palm trunk and rice straw. For oil palm trunk at its optimal location, the spatial effect is larger than the scale effect as shown by the increasing per-unit production cost. However, when distance and supply are optimised, the cost escalates at a slow and steady rate. Conversely, the magnitude of increment for biomass supply distance to non-optimal location diminishes significantly the cost efficiency from scale effect, making the per-unit production cost increase quite steeply. In the case of rice straw, the cost of optimal location and non-optimal location differ significantly, due to substantial differences in supply distance and quantities. As illustrated, the situation for biorefineries is different than conventional economy of scale. To determine the feasibility, one way is to compare the market price and manage the production cost at a lower threshold. For example, if the market price is at fifty units, both non-optimal location would not be profitable. This also highlights the importance of location factor to the success of biorefinery.

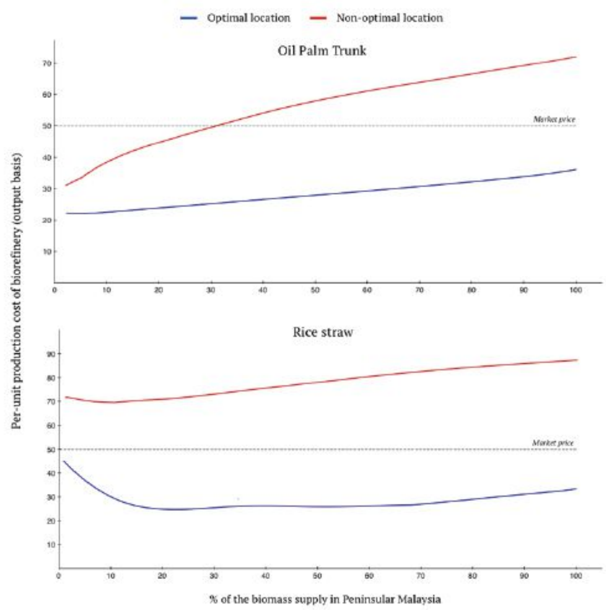

Figure 4. Estimated biorefinery production cost and biomass supply in Peninsular Malaysia

Way Forward

Today in Malaysia there is a notable potential to utilise abundant biomass residues for sustainable energy. However, there are two factors that have the most impact on biorefinery cost. One is the conversion efficiency and another is the changes in biomass spatial structure and transportation distance (Gan & Smith, 2010). With technology advancement, conversion technology could reduce its cost by improving the productivity and yields. Nevertheless, the biomass geography affects the biorefinery externally and such factor has a major importance. Fortunately, this factor can be assessed through modelling and simulations. It is important to consider the distinct dynamics of bioenergy industry for decision making and policy formulation. This could minimise the difficulty in developing alternative energy for our sustainable future.

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