

Chapter 18

Multi-Criteria Decision Making for Supplier Selection in Biomass Supply Networks for Bioenergy Production

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ABSTRACT

Decision-making on outsourcing biomass supply operations for bioenergy production is both of strategic and operational importance and can be modeled as a multi-perspective supplier selection problem characterized by multiple qualitative and quantitative factors, as well as technical and non-technical attributes and constraints. The biomass supply system presents unique features that highly impact the bioenergy production. Network functionality, raw material availability (influenced by seasonality, weather/ climate conditions, land suitability, and other parameters), and procurement costs constitute important parameters for the viability of bioenergy production plants. This chapter provides a comprehensive analysis of biomass supply chains, focusing on the special issues of raw material cost fluctuations, biomass seasonality, and the dynamics of biomass demand. It also suggests the effectiveness of a multi-criteria decision making approach for adequately assessing imprecise and uncertain biomass supplier profiles based on Intuitionistic Fuzzy Sets (IFS) in conjunction with a multi-period optimization framework for selecting the best biomass supply mix at a maximum total purchasing value.

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INTRODUCTION

Outsourcing is one of the key strategically oriented decisions in Supply Chain Management. It has been extensively shown that outsourcing decisions have significant strategic and operational implications and greatly influence several performance objectives across the entire business (Aron & Singh, 2005, Harland et al., 2005, McIvor et al, 2009, Sanders et al, 2007). Making the right outsourcing decisions can result in lower costs and competitive advantage, whereas poor outsourcing decisions can lead to increased costs, operational breakdowns, disrupted services and even an overall business failure. Efficient and effective outsourcing decision making in an organisation requires a clear understanding of its corporate strategy, core competencies, potential risks and overall costs, as well as a thorough justification of possible outsourcing arrangements for meeting business objectives (McIvor et al., 2009, Sanders et al., 2007).

Systematic decision-making is particularly significant in problems of outsourcing biomass supply operations for bioenergy production (Frombo et al., 2009). If a biomass production/processing operation is considered of strategic importance to the corporate, the option of keeping it in-house needs to be explored. From an operational point of view, if the corporate is already engaged in biomass supply operations and its performance is considered superior and/or its operations performance improvement is likely, outsourcing may not be a solution. Thus, if the corporate does not intend to expand towards this strategic direction and/or does not acquire specialized knowledge in biomass production/processing, outsourcing options may be the case.

So far, there is a low degree of (and often a lack in) strategic and operational integration between biomass suppliers and buyers, mainly due to the complexity of this kind of supply chains, compared to the traditional ones, and the existence of binding requirements for joint efforts from all relevant

stakeholders, such as government organizations, industries, parties from the agricultural sector, consumer organizations etc. For the development of a healthy and sustainable bioenergy sector there is a need for establishing a well-functioning and flexible biomass market that can ensure reliable and sustainable biomass supplies. Towards this direction, there is a number of research studies suggesting various supply chain arrangements and coordination options, as well as possible contractual agreements between buyers and sellers with the aim to ensure supply and demand over a strategic time horizon (Gjerdrum et al, 1999, Lee and Chu, 2005, McCormick & Kaberger, 2007).

A biomass supply system presents several unique features that highly influence the bioenergy production and requires special technical and managerial knowledge (Van Dyken et al., 2010). Decision making on outsourcing biomass supply activities needs to take into account the complexity of their characteristics, such as: i) the dynamics of the demand in the production system, ii) biomass-specific features, such as time dependent availability (e.g., seasonality, yield) in terms of biomass quantities and types, iii) the disperse nature of the supply chain's locations, as well as iv) certain biomass properties and quality characteristics (e.g., moisture, bulk density, energy density, energy yield etc.), which are important for the supply network functionality. Handling, collection and pre-processing/pre-treatment of biomass are influenced by biomass properties, process technologies and equipment used and all these factors have a critical impact on the whole bioenergy production system. Procurement costs are also vital for the bioenergy production viability. Cost fluctuations for various biomass types determined in a complex manner by continuously changing aggregate demand and supply conditions, along with the uncertainty of biomass availability and properties, may dictate alternative supply options to be considered by the decision makers with respect to the planning period. Furthermore, of significant interest is re-

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