An Excel-Based Decision Support System for Supply Chain Design and Management of Biofuels

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ABSTRACT

This article presents a Decision Support System (DSS) to aid managers with supply chain (SC) design and logistics management of biomass-for-biofuel production. These tools play a very important role in efficiently managing biomass-for-biofuel SCs and have the potential to reduce the cost of biofuels. The proposed model coordinates the long-term decisions of designing a SC with the medium term decisions of logistics management. This system has the ability to (a) identify locations and capacities for biorefineries, given the availability of biomass and costs; (b) estimate the minimum cost of delivering biofuels, which include transportation, investment, and processing costs; and (c) perform sensitivity analyses with respect to a number of parameters. Visual Basic for Applications (VBA) is used to create the interface of the DSS, and Excel’s CPLEX Add-In is used to solve the mathematical models.

Keywords: Biofuel, Biomass, Decision Support Systems (DSS), Ethanol, Supply Chain Design, Supply Chain Management, Visual Basic for Applications

1. INTRODUCTION

Identifying a sustainable energy source is necessary because fossil fuel demand is increasing, even as its availability is decreasing, its price is rising, and environmental concerns are growing. Research efforts have been concentrated in developing the technologies necessary for producing ethanol from corn and lignocellulosic biomass (Aden et al., 2002). The Biofuels Security Act of 2007 establishes renewable fuel standards, mandating 10 billion gallons of
renewable fuels by 2010, 30 billion by 2020, and 60 billion by 2030. In response to this act, biofuel production has increased. The Renewable Fuels Association (RFA) reported that in 2010, America’s ethanol production soared to 13 billion gallons, replacing an equivalent of 445 million barrels of gasoline. Additionally, this increase in domestic ethanol production helped support the addition of more than 400,000 jobs in the country (2010). These positive outcomes allowed the U.S. Office of Energy Efficiency and Renewable Energy’s Biomass Program to encourage more collaborations of industry, academia, and national laboratories to create a balanced portfolio of research in biomass feedstock and conversion technologies. The objective is to transform renewable biomass resources into cost competitive, high performance biofuels.

A recent study by the Oak Ridge National Laboratory indicates that, while the biomasses needed to achieve the goals set by Biofuel Security Act of 2007 are available, these resources are inaccessible because the current biomass supply systems have unfavorable transportation costs (Perlack et al., 2005). In fact, these high transportation costs can be reduced by better logistics management to supply biomass to biorefineries and to distribute biofuels to markets. A holistic approach is necessary to tackle this logistic and SC management problem. The processes of harvesting, handling, storing, and transporting feedstock must be addressed collectively to create practical, commercially viable biofuel production systems.

The models in support of the design and management of biomass-for-biofuel SC should take into consideration the characteristics of biomass. For example, production of biomass feedstock, such as corn, soybean, forest products, agricultural residues, and forest residues, etc., is limited by the amount of land available. Biomass feedstock production is seasonal, and losses of harvested biomass matter over time. Biomass feedstock transportation and handling costs are high due to the fact that biomass is bulky and dispersed over wide geographic locations. Therefore, developing models to design and manage biomass SCs and taking these characteristics into consideration is very important (Eksioglu, Acharya, Leightley, & Arora, 2009).

This article presents a DSS which helps with the design and management of the biomass-for-biofuel SC. This DSS takes into consideration the particular nature of biomass. While corn-based ethanol is the largest substitute for gasoline (USDA, 2010), concerns remain about resource competition between feed, food, and fuel, as well as the corresponding implications on food prices in third world countries (Babcock, 2011). Therefore, we found also considered design and management tools for lignocellulosic-based ethanol (c-ethanol). The DSS consents to a three-tier SC for production of c-ethanol and a four-tier SC for production of ethanol.

In the four-tier ethanol SC, the first tier corresponds to the harvesting sites, where biomass is produced and harvested. The second tier represents corn elevators, or other biomass storage and preprocessing facilities, which store the product for use outside the harvesting season. The third tier represents biorefineries, where biomass is processed and converted to biofuels. The fourth tier represents the market. Unlike corn, the harvesting of lignocellulosic biomass in the form of forest residues is not seasonal. Therefore, the c-ethanol SC is a three-tier chain because it has no need for storage facilities, the second tier in the ethanol SC.

The proposed model is expected to be used by investors in the biofuels industry. In fact, we built this system for Mississippi Technology Alliances (MTA), a non-profit organization that has the goal of bridging the gap that exists between the academia and practitioners. MTA plans to use this Excel-based DSS to aid investors with their facility size and location decisions. Since MTA employees are familiar with Excel, we decided to build the interface of this DSS in Excel using VBA for Excel and the CPLEX Add-in (IBM, 2012) to solve the corresponding mathematical models.

The DSS uses an interactive software-based system intended to support decision
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