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Evaluation of the impact of water supply disruptions in bioethanol production

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ABSTRACT

Factors such as raw materials availability, production capacity, technology, and costs promote the development and feasibility of supply chains. However, some other factors are more than important for supply chain development; they are essential. In the context of biofuel supply chains, water is a crucial factor; nevertheless, scientific research has not yet analyzed how water scarcity can compromise the performance of these supply chains. To address this gap, this research analyzes as a case study a leading company in Mexico that produces and distributes biofuel in the country. Lately, the company has experienced serious production stoppages due to water supply disruptions. This work develops a system dynamics simulation model to evaluate, by means of a sensitivity analysis, the effects of water supply disruption on industrial production and biofuel demand satisfaction in four duration periods: 8, 12, 24, and 48 h. The results indicate that production disruptions due to water scarcity can be avoided by reducing the mash flow that feeds the distillation column as long as the water scarcity period lasts no more than 12 h. Similarly, it was found that demand satisfaction decreases when the scarcity period lasts for 24–48 h, yet demand satisfaction remains stable when water disruption lasts less than 24 h. The findings also indicate that when demand increases by 20%, it is impossible to fulfill it in any case. Therefore, several scenarios designed to improve demand satisfaction were evaluated.

1. Introduction

Biofuels such as bioethanol and biodiesel are alternative energy sources that can potentially reduce oil dependency. They provide energy security and contribute to the reduction of greenhouse gas emissions (Azadeh & Vafa Arani, 2016; Azadi, Malina, Barrett, & Kraft, 2017; Khatiwada, Venkata, Silveira, & Johnson, 2016). Governments around the world encourage the use of biofuels, which has led to a rapid increase in their production (BiofuelsDigest, , 2016). Currently, bioethanol is the most used biofuel worldwide due to its low fabrication costs (IEA, 2011). From 2007 to 2015, the world's bioethanol production increased in 95.7% (Fig. 1), and this upward trend is expected to continue in the future (Gheewala et al., 2013).

Bioethanol production relies on large volumes of water across its different supply chain stages (Fingerman, Torn, O'Hare, & Kammen, 2010). Even though industrial ethanol production requires much less water than raw material production (Fachinelli & Pereira, 2015), the environmental impact is still worrisome. Water used for crop irrigation comes from the rain, while water used in industrial processes is withdrawn from aquifers since high quality is needed (Mosqueira-Salazar, Palacios-Bereche, Chávez-Rodríguez, Seabra, & Nebra, 2013). Furthermore, bioethanol plants must be located in specific geographic zones, so their overall water demand causes stress in aquifers.

Securing water requirements for bioethanol production is not an easy task (Gheewala et al., 2013). Water is becoming a globally scarce resource as a result of an increased global population and a rapid agricultural and industrial growth (WWAP, 2015). Since water scarcity compromises the operations and future development of the bioethanol

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