Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 12 (2016) 938 – 949

Transportation Research Procedia

www.elsevier.com/locate/procedia

The 9th International Conference on City Logistics, Tenerife, Canary Islands (Spain), 17-19 June 2015

Supply chain optimization of biodiesel produced from waste cooking oil

Yunjian Jiang, Yong Zhang*

School of Transportation, Southeast University, No.2 Sipailou, Nanjing, 210096, China

Abstract

Producing biodiesel using waste cooking oil is a substantial instrument for solving the intense problems caused by energy crisis and environment pollutions. This paper focuses on the design of the biodiesel supply chain using waste cooking oil as feedstock in China and establishes a mixed integer linear programming model for both economic and environmental optimization. The model considers a three level network including waster cooking oil production points, distribution centers and factories. And four aspects of decisions are made: (1) the number of distribution centers and factories to locate; (2) the locations of the distribution centers and factories; (3) the allocations of the waste cooking oil among supply chain members; (4) the decisions of factories' technology choice. Finally, the model is applied to a real network in Nanjing and the genetic algorithm is developed to solve this problem.

Peer-review under responsibility of the organising committee of the 9th International Conference on City Logistics

Keywords: Waste cooking oil; Supply chain; Mixed integer linear programming; Genetic Algorithm;

1. Introduction

China has become the world's largest producer of energy-related carbon dioxide since 2007, and the emissions are estimated to be still increasing until 2030. In 2012, fossil oils sector accounts for 35.3% of carbon dioxide emissions worldwide, and ranked the second largest sector (IEA, 2014). Transportation sector is known as the most

* Corresponding author. Tel.: +86-25-8379-0074; fax: +86-25-8379-0074.
E-mail address: zhangyong@seu.edu.cn

Peer-review under responsibility of the organising committee of the 9th International Conference on City Logistics
doi:10.1016/j.trpro.2016.02.045

rapidly growing sector (Yan and Crookes, 2009), which has consumed nearly one-third fossil oils in China and emitted one-quarter carbon dioxide worldwide in recent years. Therefore, alternative fuels for transportation is widely studied for energy and environmental concerns (Stella et al., 2012), of which biodiesel is one kind of the most promising energy in this regard (Iddrisu and Zhang, 2012).

Biodiesel is a nonpetroleum-based fuel defined as fatty acid methyl or ethylesters derived from vegetable oil or animal fats (Felizardo et al., 2006), whose physical properties is very similar to conventional diesel (Kahraman, 2008). It can either entirely or partially substitute the diesel oil used in automotive engines in trucks, tractors and cars as well as stationary machines, such as power and heat generators (Juliana et al., 2011). Besides that, biodiesel has other advantages in fossil fuel substitution, such as (i) decrease in air pollution emissions; (ii) no increase in the CO_2 content in the air compared to fossil fuels; (iii) efficient resource and/or waste utilization; and (iv) decrease in the volume of imported fossil fuels (Ampaitepin et al., 2010).

Unfortunately, biodiesel is uncompetitive in price for high costs (Zlatica et al., 2008) as well as immature technology. It's estimated that feedstock cost takes up about 75%-80% of the total cost in biodiesel production, thus low-cost feedstock, such as Waste Cooking Oil (WCO), is gaining attentions (Man et al., 2010). WCO can be divided into three categories, including the oil extracted from floating fatty in sewer or leftovers, the oil extracted from low-quality pork or pig offal as well as the oil that fried foods exceed the required time and reused (Wu, 2008). China has produced considerable WCO annually (about 4-8 million tons), and half of them can be collected (Fu et al., 2005).

However, WCO is scattered in production points (restaurants, hotels, households etc.), and its collection problem may be an important bottleneck that limits its development. A professional recycling logistics system of WCO, especially the design for door-to-door collection service and recycling facilities, may help to solve this problem (Zhang et al., 2012). Thus the supply chain optimization is essential and meaningful for WCO to biodiesel industry, and it's the focus of this paper.

2. Literature review

In recent years, WCO has proved to be a promising biodiesel feedstock for both economic and environmental considerations. L.Talens et al., (2010) adopted life cycle assessment and an exegetic life cycle assessment to assess the environmental impact and the energy input to WCO-to-biodiesel system for producing 1 ton of biodiesel, and Javier et al., (2012) concluded biodiesel from WCOs potentially entailed the most favorable environmental performance.

WCOs-to-biodiesel industry has been widely discussed in different counties/regions (China, the USA, Taiwan etc.). Sai et al., (2013) estimated the WCOs-to-biodiesel production in China, and concluded its greenhouse gas mitigation potential and fossil-based diesel substitution would be up to nearly one quarter and one half, respectively. Similarly, Claudia et al., (2013) evaluated the WCOs-to-biodiesel production in Mexico, and the results showed that the potential of biodiesel from WCO could represent 1.5-3.3% of petro-diesel consumption for the road transport sector and reduce 0.51-1.02 Mt of CO_2. Tsai et al., (2007) analyzed the energy utilization from WCO for the diesel production in Taiwan. Those studies consistently implied that producing biodiesel from WCO helped to substitute a considerable proportion of fossil-based fuels.

Besides that, some scholars found WCO was more suitable when the producing scale is not so large. Loreto et al., (2012) compared the two biodiesel production systems (centralized and decentralization production), and found that centralized production was more suitable in small territories, while decentralization was more advisable as the territory increased in area. Adam et al., (2013) simulated biodiesel production from soybean oil or WCO, and found that the soybean oil based process is not economical at such small scales, whereas the waste oil case has an internal rate of return of 80%.

Although numerous studies had examined the environmental and economic feasible of WCO-to-biodiesel industry, this industry still faced a huge challenge in China. Zhang et al., (2012) designed a structured questionnaire to survey 246 restaurant enterprises in Nanjing and analyzed the status, obstacles and recommendations for WCO of restaurants as biodiesel feedstock in China from supply chain' perspectives. Zhang et al., (2012) analyzed the policy documents of WCO in China for two dimensions (basic policy tools and enterprises supply chain), and suggested market-oriented initiatives should be enhanced for WCO-to biodiesel production.