Reliability Engineering and System Safety 174 (2018) 96–107

Contents lists available at ScienceDirect

Reliability Engineering and System Safety

journal homepage: www.elsevier.com/locate/ress

Designing a bio-fuel network considering links reliability and risk-pooling effect in bio-refineries

F. Salimi, Behnam Vahdani*

Department of Industrial Engineering, Faculty of Industrial and Mechanical Engineering, Qazvin Branch, Islamic Azad University, Qazvin, Iran

ARTICLE INFO

Keywords:
Bio-fuel supply chain network design
Risk-pooling
Reliability
Link failure probabilities
Bio-refinery disruption

ABSTRACT

Bio-fuel is one of the most important alternatives to fossil fuels due to energy shortages. The bio-fuel is derived from biomass that is obtained from agricultural products such as plant debris. In addition, the supply chain is affected by risks which are due to several reasons such as economic, natural phenomena, political and etc. The occurrence of such events can cause disruption in supply chain which can significantly increase the total supply chain costs and also prevent serve to customers. Reliability is involved the capability of a network to achieve an anticipated process such as “communication". Analysis of network reliability has acknowledged significant consideration and is consequently broadly studied to forecast and avoid any network failure. In order to distribute bio-fuel to the customers, designing a reliable and sustainable bio-fuel supply chain is very importance. Thus a growth in bio-fuel production demonstrates the requirement for establishing an effective and reliable network of chain that not only accomplishes sound under regular circumstances nevertheless restricted risk under various unanticipated disruption situations. This paper presents mathematical model to design an efficient bio-fuel supply chain network at pre-disaster stage that considering failure in the connecting links between the facilities. In which the probability of failure of the links is forecasted by a spatial statistic approach and also due to the fact that disasters can cause disruptions in bio-refineries, leads to use the risk-pooling effect in order to reduce total costs. In order to solve the proposed mathematical model, two meta-heuristic algorithms containing genetic algorithm (GA) and bat algorithm (BA) are utilized. The results show that by increasing the reliability and improvement of connecting links between facilities and considering the risk-pooling effect on disrupted bio-refineries, the total costs of supply chain can be considerably reduced.

© 2018 Elsevier Ltd. All rights reserved.

1. Introduction

The growing of population, alterations in the society, and increasing in living criteria have altogether led to an upsurge in the consumption of energy in the worldwide, specifically, in the developed nations. What is known today as a global problem is the shortage of energy, which is by reason of using fossil fuels. In order to solve the problem and guarantee upcoming energy confidence and sustainable energy and the investigation and design of a reliable network has apprehensive the consideration of investigators. Furthermore, analysis of network reliability in various circumstances is vital to forecast and avoid network failure. Bio-energy facilities, only part of the solution to this problematic issue, have concerned more consideration in current decades since they can be suitable alternatives for the old energy facilities. Energy from bio-fuel production is one of the most important renewable energy that includes a varied collection of fuels that are emanated from biomass [34]. Similar to the other supply chain networks, bio-fuel supply chain has different levels such as farmers, bio-refineries, oil companies and customers and etc. A bio-fuel chain incorporates completely actions from purchasing raw material, transporting of biomass, producing of bio-fuel, and delivery of products to the final consumers [24]. A series of destroying cases in latest decades, such as Hurricane Katrina, earthquakes and oil spill are only some instances of events that depict the bio-fuel supply chain infrastructure is susceptible to several disruption dangers that their occurrence may disrupt the usual performance of bio-fuel chain network. If transportation links and facilities fail, several times may be needed to reestablish. Thus, the existence of a bio-fuel supply chain network that performs well under various unexpected disruption scenarios is undeniable [31,41].

The issues of reliability and resilience of the bio-fuel supply chain in response of natural disasters have been attracted interest of many researchers. Snyder and Daskin [37] proposed a mathematical model for reliable un-capacitated fixed-charge Location Problems (UFLP), where, facility disruptions occur randomly with identical probability. Zhan et al. [56] and Qi et al. [32] have shown that different failure probabilities for facilities at different locations may have significant impact

* Corresponding author.
E-mail addresses: b.vahdani@ut.ac.ir, b.vahdani@gmail.com (B. Vahdani).

https://doi.org/10.1016/j.ress.2018.02.020
Received 4 June 2017; Received in revised form 5 February 2018; Accepted 13 February 2018
Available online 14 February 2018
0951-8320/© 2018 Elsevier Ltd. All rights reserved.

on site selection and location of facilities. Zhan et al. [56] studied the location of facilities in the unreliable facility location problem with single and multi-levels. They proposed a mathematical model by considering unreliable facilities. To solve the presented model, they developed efficient algorithms based on genetic algorithm. Cui et al. [7], Li and Ouyang [21], Shen et al. [36] and Li et al. [23] extended present formulations by relaxing the probability of disruption presented by Snyder and Daskin [37]. Li et al. [22] developed continuous and discrete models to design reliable bioethanol supply chain. They used mathematical examination to assess the influence of disruptions on plant deployment decisions. Zhang et al. [57] extended a facility location model that considered the facilities disruptions and economical issues from the risk-pooling approach, in which some facilities may have disruption probabilities. Fiondella et al. [12] presented a mathematical model to maximize the confidence in goods productivity, allowing flexibility during design. Almost completely reliability optimization models suppose that failures of factors are s-independent but their research did not execute this assumption. Selvik and Signoret [35] pointed that different interpretations of the term 'safety critical failure' exist. Their article indicated in general to the importance of adequate risk communication when using the term, and gives some clarification on interpretation in risk and reliability assessments.

Furthermore, various researches are carried out in the literature to identify the optimal locations of bio-refineries to minimize the supply chain total costs. These studies have developed integrated bio-fuel chain networks to distribute bio-fuel with competitive price to the final consumers. Zamboni et al. [54], Eksioglu et al. [9,10] developed mathematical models to optimize the total plant establishment and costs of transportation in the bio-fuel supply chain. Xie and Ouyang [50] developed a mathematical programming model for a facility location problem under dynamic condition, which aimed to minimize the total costs including opening facility, expansion of capacity and transportation. Moreover, they used an exact algorithm to solve large-size instances. In addition, demand uncertainty is another factor which can significantly influence the supply chain network design, because it can affect decisions related to location, allocation and inventory levels at the facilities [28]. In the literature, one of the most appropriate methods to deal with uncertainty in demand parameter is risk-pooling strategy [5,42,44,45]. Risk-pooling method aims to adjust inventory levels in order to satisfy the demand and achieve better service levels. Previous researches such as Kulkarni et al. [19], Gerchak and He [13], Alfaro and Corbett [1] and Vahdani and Mohammadi [46] indicated that the use of this strategy is one of the most effective methods to reduce costs at different levels of supply chain. Since demand is different from market to market, the high demand of a market can be integrated with lower demand than the other market and balanced them. This leads to a reduction safety stock and ultimately reduces the amount of inventory and reduces costs. In the other words, in this method, the demand related to supply chain members that received service form the same facility, are integrated or classified, to planning more accurate [8]. Hence, disasters including natural disasters and their influence on the supply chain efficiency cannot be ignored, designing a reliable bio-fuel supply chain that satisfies demand in the case of an emergency situation is essential. To the best of our knowledge no research has been conducted to consider link failure probability between facilities and disruption in the bio-fuel supply chain refineries at the same time.

Another research area which has been studied widely in the literature is the uncertainty in supply chain of bio-fuel. For instance, Kim et al. [18] proposed an uncertain mathematical model for designing a biomass supply networks. Also, they applied their suggested model on a case study which is related to USA. In various real situations, most of the parameters of the mathematical models presented for bio-fuel supply chain network design are due to uncertainty that can considerably influence the efficiency of the supply chain. To capture system uncertainties, Chen and Fan [6] and Huang et al. [17] developed uncertain models to effective design and controlling of bio-fuel supply chain networks. Huang et al. [17] proposed an effective bio-fuel supply chain network to deal with seasonal variations and uncertainties of feedstock supply in an integrative manner. The main assumptions of these researches are that facilities are resistant and never fail. Wang et al. [49] and Bai et al. [2] integrate the risk of bio-refinery disruptions in organizing bio-fuel supply chain networks. Ren et al. [33] investigated a bi-objective interval mix integer programming model to design bio-fuel supply chain under uncertain condition.

An additional aspect of study has been led to propose link improvement facilities for calamity situations. Sohn [38] and Bana e costa et al. [3] studied focused on specific factors to the physical features of the connection links and the cost to improve them. Peeta et al. [30] considered a pre-disaster planning problem that facilitated and sought to the connectivity for first responders between various origin–destination pairs. Poudel et al. [31] presented a pre-disaster planning model that assumed the failure of links and sought to reduce or elimination the risks and reinforce connection links with limited budget constraint. Despite all these efforts, a model that considers both link failure probabilities and bio-refinery disruptions that by taking these assumptions is looking for increase network communications after disasters has not been thoroughly studied. Based on above mentioned description, this paper proposes a pre-disaster planning model that seeks to reinforce connection links and increase the reliability of the bio-fuel supply chain network and reduce the bio-fuel supply chain costs subject to budget constraints and considering the risk-pooling effect.

Furthermore, considering that the natural disasters can cause disruption in the bio-fuel supply chain infrastructure, increase total supply chain costs and disrupt the customer service, it is required to design a reliable supply chain network that can decrease costs and satisfy demands under disruption scenarios. To address this issue, this paper aims to develop a new mathematical model to design a reliable bio-fuel supply chain network that considers natural disasters and analyzes the impact of failure probability to minimize the supply chain costs. It should be noted that, although the present model has been developed for bio-fuel supply chain network, but because that model is comprehensive so it can also be used in other supply chain networks.

The rest of the paper is organized as follows. Problem definition and formulation are described in Section 2 in detail. The proposed solution approach is given in Section 3. Computational experiments are provided in Section 4. Case study is presented in Section 5. Finally, the paper is concluded in Section 6.

2. Problem definition and formulation

The bio-fuel supply chain which is considered in this paper consists of four levels including biomass supply, loading and unloading terminals, bio-refineries and consumers. The biomass is transferred from suppliers to loading and unloading terminals then from terminals to refineries to satisfy consumers demand. This paper aims to propose a new mathematical programming model for designing a pre-disaster reliable bio-fuel supply chain network. The presented model in this research considers link failure probability between facilities and disruption in facility, simultaneously. Considering various operational constraints such as budget constraint, the mathematical model aims to increase reliability and strengthen the links between the facilities, satisfy customer's demand and reduce the total supply chain risks and costs. It is assumed that the location of the biomass supply centers is known. While, the aim is to determine the location of bio-refineries from a given set of potential locations. Disruption of the bio-refineries can cause uncertainty in demand parameter. To cope with this issue, risk-pooling effect is considered where the customers assigned to a failed bio-refinery are reassigned to another operating bio-refinery.

In this paper initial allocation is allocation of customers to the bio-refinery in normal conditions, supportive allocation is customer allocation to the bio-refinery when disaster occur and in the critical situation that customers are reassigned to the surviving bio-refineries. A

Download English Version:

https://daneshyari.com/en/article/7195202

Download Persian Version:

https://daneshyari.com/article/7195202

Daneshyari.com