Chapter 11

Multi-Criterion Decision-Making Analysis for Sustainable Bio-Fuel Supply Chain

Thangaraja J.
VIT University, India

Vijayakumar M.
National Institute of Technology Warangal, India

Yatharth Gupta
VIT University, India

ABSTRACT

Present estimates indicate India's bio-fuel demand as 0.5 billion gallons in 2012 which will grow to 6.8 billion gallons by 2022. While fossil fuel science and technology is well established, the scientific understanding and technological implications of biofuels are not clearly laid out. In recent years, a large number of assessments have been conducted to assess the greenhouse gas (GHG) emissions of biofuels. However, contradicting results were noted in the published articles. The current chapter attempts to understand the importance of triple bottom line (TBL) aspects for the life cycle sustainability analysis (LCSA) over the conventional life cycle analysis (LCA) of biofuels-based supply chain. Along with energy and environmental indicators, LCSA also evaluates the economic and social factors. Hence, a statistical assessment with multi-criterion decision-making (MCDM) analysis has been implemented to highlight and achieve coherence in conducting the sustainability analysis of biofuels supply chain.

INTRODUCTION

The majority of fossil fuel, viz. petrol or diesel is consumed by the transportation sector. The present estimates indicate that the demand for fossil fuel is increasing significantly. This rapid increase has adversely affected the environment through greenhouse effect and global warming. In order to meet the growing demand for energy, there is a need for a sustainable alternative fuel. Biofuels have emerged as a promising option to displace the fossil fuel consumption. Extensive research, with respect to the DOI: 10.4018/978-1-5225-5424-0.ch011
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biofuel production, property characterization, engine performance and emission studies are conducted and their potential as alternative fuels have been assessed (Talebian-Kiakalaieh, Amin, & Mazaheri, 2013; Stumboarg Wong, & Hogan, 1996; Thangaraja Anand, & Mehta, 2016; Sarin, 2012; Ramos, Fernández, Casas, Rodríguez, & Pérez, 2009; Rajkumar & Thangaraja, 2016; Thangaraja & Pramod, 2015; Thangaraja, Anand, & Mehta, 2014). However, considering the Indian scenario, it is important to access the life cycle sustainability analysis of biofuels to make them as a viable option in near future.

A plethora of literature is available regarding the sustainability analysis of biofuels. These literatures include field research, optimization analysis and impact assessments on social aspects of biofuels. An investigation was carried out to understand the benefits and limitation of the biofuels industry in order to achieve sustainable fuels (Jidon & Naoko, 2010). A framework was also developed for evaluating the biodiesel sustainability from vegetable oils (Mio, Posocco, Laurini, Pricl, & Fermeglia, 2017). A study about the sustainability of biofuels through the supply chain technique and to understand the future perspective and sustainability of biofuels for the U.S. energy portfolio (Jennifer & Bruce, 2016) was conducted. The integration of the notion of production cost ratios and life cycle energy efficiency have been carried out for the sustainable assessment of biofuels (Menghsan & Walter, 2016). Further studies were conducted to study the new trends which have been directed towards the enhancement of production of biofuels and analyzed them on the basis of their sustainable energy production.

Selection of the most optimized alternative for the sustainability of biofuels can be considered as a complex multi-criteria decision making (MCDM) problem and demands an extensive evaluation process. MCDM involves selection of best-suited option from the set of alternatives, each of which is analyzed against multiple criteria. Previously there was study aimed at identifying the critical success for promoting sustainable development of biofuel industry in China using multi-criteria decision making. The multi-criteria decision-based methodology which integrates the key factors involved in the transport system along with the sustainability issues and also showcased a case study based on Spain for the impact assessment of liquefied natural gas (LNG) in comparison to hydrotreated vegetable oil (HVO) and diesel oil as transportation fuels. The systems to support policy formation for sustainable biofuels production based on multi-criteria analysis was done in this field.

Different MCDM models such as VIKOR, ELECTRE, PROMETHEE, KANO, and TOPSIS have diverse approach and effectiveness depending upon the problem to be analyzed. Among all the MCDM techniques mentioned above, TOPSIS is the best-suited technique and hence have been used to find the optimized ranking of alternatives based on the described criteria. TOPSIS is an MCDM technique which was initially proposed by Hwang and Yoon (Hwang & Yoon, 1981). The logic behind fuzzy approach to TOPSIS is to hypothesize two artificial alternatives Fuzzy Positive Ideal alternative and Fuzzy Negative Ideal alternative. Where the Fuzzy Positive Ideal alternative describes the best values of all the criteria. Whereas on other hand Fuzzy negative ideal alternative describes the worst values of all the criteria considered for the problem. In the TOPSIS approach, an alternative which is most near to the Fuzzy Positive Ideal Solution (FPIS) and farthest from the Fuzzy Negative Ideal Solution (FNIS) is chosen as to be optimal (Qin, Huang, Chakma, Nie, & Lin, 2008). TOPSIS can be also generalized in a fuzzy based environment after which the problems regarding fuzzy multiple criteria decision making can be effectively and efficiently solved using this technique (Chen, 2000). Because of its flexibility and simplicity in implementation, also an easy procedure based on geometric representation, it is considered to be one of the most recommended MCDM methods. the assessment in order to find the of a most optimized methodology based on TOPSIS approach for location selection for biofuel refinery in order to increase the sustainability of biofuels.