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A Quantile-Based Scenario Analysis Approach to Biomass Supply Chain Optimization under Uncertainty

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Abstract

Supply chain optimization for biomass-based power plants is an important research area due to greater emphasis on renewable power energy sources. Biomass supply chain design and operational planning models are often formulated and studied using deterministic mathematical models. While these models are beneficial for making decisions, their applicability to real world problems may be limited because they do not capture all the complexities in the supply chain, including uncertainties in the parameters. This paper develops a statistically robust quantile-based approach for stochastic optimization under uncertainty, which builds upon scenario analysis. We apply and evaluate the performance of our approach to address the problem of analyzing competing biomass supply chains subject to stochastic demand and supply. The proposed approach was found to outperform alternative methods in terms of computational efficiency and ability to meet the stochastic problem requirements.

Keywords: uncertainty, scenario analysis, optimization, renewable energy systems, biomass

1. Introduction

Presently, fossil fuels such as oil, coal and natural gas are the prime energy sources of the world. However, it is anticipated that these sources of energy will be depleted within the next 50 to 100 years (Hughes & Rudolph, 2011; Kerr, 2012; Saidur et al., 2011). The world is consuming more fossil fuel for energy than is being discovered and the reserves of energy that can be cheaply mined have reached peak production (Hughes & Rudolph, 2011; Kerr, 2012; Saidur et al., 2011). Moreover, the expected environmental damages, such as global warming, acid rain and urban smog due to the production of emissions from the combustion of fossil fuels have compelled the world to reduce carbon emissions and shift towards utilizing sustainable and renewable energy sources (Saidur et al., 2011). Biomass has been recognized as a promising alternative feedstock for energy production, since it is both renewable and CO_2 neutral (Rauch & Gronalt, 2010). However, renewable energy production from biomass faces many challenges due to uncertainty of its demand and continuous supply (Ebadian, 2013; Yue et al., 2014).