

## Feedstock and Technology Options for Bioethanol Production in South Africa: Technoeconomic Prefeasibility Study

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### Abstract

The production of fuel grade ethanol from nonfood grade crops in South Africa has the potential to reduce reliance on imported oil and minimize the negative environmental consequences of fossil fuels. This article presents a preliminary assessment of the technical and economic feasibility of producing fuel-grade ethanol from nonfood, small grain crops cultivated on marginal lands in the Western Cape of South Africa, namely triticale, low-grade wheat, feed barley, and malt barley. It also explores the potential of grain fiber fractionation (separation of starch from bran) on process economics for a dry-mill process. A conservative “base-case” economic model was developed for a processing capacity of 200 000 metric tonnes per annum (tpa) at maximum expected feedstock prices. The overall average unit costs of production for each grain were compared for three possible process configurations, i.e. a conventional dry-mill starch-to-ethanol plant, an advanced starch-to-ethanol plant with fractionation and energy recovery from bran, and a hybrid integrated cellulosic plant with fractionation, hydrolysis, and fermentation of bran. Triticale demonstrated the greatest economic potential of all grains, regardless of technology type, while the advanced process technology option-fiber fractionation and steam generation from bran combustion achieved the lowest overall costs of production, across all grain types. For the conservative base-case model, it was found that the government subsidy of ZAR 1.50/L proposed under the South African Biofuels Strategy is insufficient to ensure economic feasibility for any of the grains or technology options under scenarios with high feedstock costs. The government subsidy would need to be increased by at least 124% before profitable operation during times with high feedstock prices would be possible. A sensitivity analysis of the economic assumptions of the base-case model demonstrated that feedstock price is the most important determinant of production costs and that the economic feasibility of such technologies relies heavily on a favorable ethanol selling price. When assuming maximum theoretical starch–ethanol yields, and considering fluctuation in feedstock prices in the range from ZAR 1589/t to ZAR 3680/t (as observed in South Africa during the period between 2005 and 2012), the best economic results were observed for an advanced starch-to-ethanol plant processing triticale grain at a rate of 200 000 tpa (production cost between ZAR 4.25/L and ZAR 8.48/L). Due to uncertainty of commodity price fluctuations, it is recommended that static, deterministic models for economic feasibility should therefore be enhanced to incorporate uncertainty and quantitative risk assessment in process and economic parameters, by adopting stochastic simulation methods to account for price volatility.