**EXECUTIVE SUMMARY OF FINAL TECHNICAL REPORT**

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| **Project Title:** | Development of a Bulk-Format System to Harvest, Handle, Store, and Deliver High-Tonnage Low-Moisture Switchgrass Feedstock |
| **US DOE Award Number:** | EE0001034 |
| **Recipient:** | Genera Energy, LLC<br>167 Tellico Port Road<br>Vonore, TN 37885 |
| **Project Location:** | Vonore, TN |

This project evaluates and compares comprehensive feedstock logistics systems (FLS), where a FLS is defined to comprehensively span from biomass material standing in a field to conveyance of a uniform, industrial-milled product into the throat of a biomass conversion facility (BCF). Elements of the bulk-format FLS evaluated in this project include: field-standing switchgrass dry chopped into bulk format on the farm, hauled (either loose or bulk compacted) to storage, stored with confining overburden in a protective facility, reclaimed and conveyed to bulk-format discharge, bulk compacted into an ejector trailer, and conveyed as bulk flow into the BCF. In this FLS evaluation, bulk storage bins served as a controlled and sensored proxy for large commercial stacks protected from moisture with a membrane cover.

This project required a bulk-format handling facility that received, conveyed, stored, reclaimed, and discharged bulk-format switchgrass, automatically, with an effective integrated system. Multiple truck-load quantities of field chopped switchgrass were received and reclaimed from the receiving pit for introduction into conveyance. Negative-pressure and positive-pressure pneumatic conveyance systems formed a first-in, first-out loop through storage with flexibility in moving bulk-format materials. Switchgrass was transferred from pit to storage bins, from pit to compactor, recirculated among storage bins, transferred to a bin different from the source bin, or discharged from a selected bin into the compactor. Dust control integrated into the system had capability to catch and weigh the mass of dust during each activity. Two storage bins allowed for simultaneous testing of (1) changes in characteristics, handling, reclaim, and compaction of field chopped switchgrass stored up to 12 months in project experiments, and (2) reclaim, handling, and compaction engineering performance of field chopped switchgrass, coarse tub ground switchgrass bales, and fine tub ground switchgrass bales. Tub ground switchgrass had particle distributions wider than field chopped and was tested to broaden the knowledge base applicable to bales ground for bulk-format introduction into the BCF. Bin bulk densities and reclaim of bulk switchgrass were monitored to establish baseline data.

Deliberate engineering and testing of the constructed bulk-handling FLS advanced the state of knowledge useful for many feedstock supply systems. Logistics evaluation was conducted for the entire system including GPS-tracked field and over-the-road equipment, operational conditions, load weights, bulk densities, moisture contents, particle sizes, reclaim and handling throughputs (tons/hr), power and energy use (kw/ton), unit costs ($/ton), switchgrass composition and ethanol potential, and assessment of efficiencies and utilization values (%). Two storage bins allowed for simultaneous testing of changes in

characteristics, handling, reclaim, and compaction of field-chopped bulk stored material over time (12 months), and reclaim, handling, and compaction engineering performance of multiple specifications of bulk material, including field-chopped, coarse tub grind and fine tub grind.

A discovery was that field-chopped, low-moisture (13% moisture content wet basis) switchgrass exhibited desired traits of increased loose bulk density, increased compacted bulk density (comparable to bale FLS), and a significant finding of propensity for free-flow compared to tub grind switchgrass. While fine tub grind switchgrass flowed at rates more than double the rates for coarse tub grind switchgrass, the field chopped, low-moisture switchgrass flowed at rates that were three to four times the rate of any tub grind material, up to 40 tons/hr. The composition analysis for material in bulk format was similar to that in bale format, including composition over time. Costs for bulk format were highly competitive with bale systems, with additional significant potential cost and performance benefits identified for downstream BCFs.

Project addressed a more complete FLS for delivery of feedstock specification to a biorefinery. Recommendations included development of a direct-cut forage harvester header for switchgrass to eliminate the mower-conditioner harvest operation, development of on-board compaction trailers, advancement in track-less stacker-reclaimer technology for mobile deployment, implementation of membrane technology for moisture management in tall-stack storage, leverage the advantages of field chopped switchgrass flow behavior in logistics systems design, implement dust control measures as demonstrated, continue FLS development that maximizes ethanol/ product yield, and continue to update techno-economic cost analysis to reflect actual, changing costs.