



# Energy Performance Systems, Inc.

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Project Title: **“Improving the Efficiency of Planting, Tending and Harvesting Farm-Grown Trees for Energy”**

Contract Number: RD-50      Milestone: #2      Report Date: 7/26/2006  
Reporting Period: 4/16/06-7/16/06  
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Congressional District: 4 (Corporate Office and Lab; Rogers, MN)  
Congressional District: 7 (Farm Location; Glencoe, MN)  
Congressional District: 6 (Equipment Building Location; Big Lake, MN)

## **MILESTONE #2 – SUMMARY REPORT (PUBLIC)** **Design and Test Planter Injection System**

### *Executive Summary:*

The injection system and shock absorber for the new tree slip planter was designed, built, and tested successfully in the EPS shop for over 10,000 cycles of operation at a rate of 1 cycle per second. A new trigger mechanism was designed, built and tested, and it worked well after several minor modifications. Several position control limit switches failed during the testing and were replaced resulting in a design change for the six row planter. The hydraulic power supply system that was assembled for the lab tests worked well. An impact absorber for the planter was developed and the test results suggested that it would be durable enough and not over heat in the field. The tests showed that the injection speed range for the injector should be increased to allow for greater operational flexibility during field planting. This is being accomplished by lengthening the injector stroke in the six-row planter that is now being constructed. Deliverable 2 met the project goals by providing the information needed to proceed to finalizing the injector design and building all six injector systems for the planter.

### *Technical Progress:*

The six row EPS slip planter is designed to inject tree slips 10” long and 5/16” to 7/8” in diameter into the soil at the rate of 6 per second while the tractor is moving at 5 miles per hour across a no-till field. This deliverable (#2) describes the single slip injection system tests, while deliverable #4 will describe the basic six-row planter. The injection system fires the slip into unaltered soil using a recoil mechanism.

The injector test setup was approximately 10 ft high with a foot print of 6 feet square. The injector test system was successfully operated for over 10,000 cycles in the EPS shop. A hydraulic power supply was assembled and is driven by a 10 hp, 3 phase, 230 v motor coupled to a 28 gal/min two-stage hydraulic pump fed by a 20 gal reservoir. The system provided the required flow at pressures up to 3000 psi to operate the injector via two electronically controlled servo valves. For the six-row planter, hydraulic power will be provided by a John Deere tractor

model 8130 with 240 peak horsepower and a 60 gpm hydraulic pump capable of 2900 psi. Two micro switches with their associated control valves and a mechanical stop controlled injector positioning. Early in the testing the micro switches failed and were replaced. As a result proximity detectors have been purchased for the 6-row planter. The micro switches and a “smart relay” (Programmable Logic Controller -- PLC) programmed by a laptop computer controlled the injection cycle timing.

High stress parts of the injection system were made with 4340 heat-treated steel to obtain the necessary strength. This material is more difficult to work with but the high strength to weight ratio is vital for this application. However, the 1026 DOM mild steel was observed to gall because of the sliding pressures created by the 4340 steel injector. After repairs were made, retesting using a non-sulfinated slide lubricant eliminated the problem. Surprisingly, extreme pressure lubricants were found to be unacceptable for this application. The critical trigger mechanism that was designed worked well after several relatively minor corrections. The new shock absorber that was designed and fabricated held up well, and the material tested was adequate. The injector and shock absorber dynamics were observed using a high-speed camera (Red Lake camera and recorder at 500 frames/second and Fastex camera at 4000 frames/second).

A computer model of the injector travel was developed to facilitate the design. Using the measured mass of the injector, the observed impact velocity compared favorably to the model. The testing and modeling showed that the injection speed needs to be increased to meet field planting criteria; this will be accomplished by lengthening the injector stroke in the six-row planter that is now being constructed.

Additional text and five proprietary figures are given in the confidential version of this milestone report.

***Additional Milestones:***

*M1-Annual Land Rental:* Completed, deliverable report provided 4/20/2006.

*M2-Design & Test Planter Injection System:* Reported herein.

*M3-Tree Slip Purchase & Tractor Rental:* Completed, deliverable report provided 4/20/2006

*M4-Basic Planter:* Parts production is about 98% complete, and the planter assembly is about 80% complete as of 7/20/2006. Delays in assembly are primarily due to a lack of a few specialty parts which were being made by subcontractors. A three-week final assembly will begin when all parts are available.

*M5-Test Planter:* Upon complete assembly of the planter, the first test will be made on a 10 acre piece of land in Rogers, MN. When deemed ready, the tractor and planter will be moved to the Glencoe site for the planting of approximately 20,000 trees on part of the 80 acre site.

*M6-First 80 Acre Planting:* Since planting of the hybrid poplar cuttings could not be delayed until the planter was fully tested and ready for operational scale planting, an experienced tree planting team was hired to plant the site. The team planted on the dates of June 14-17<sup>th</sup>. About 60 acres was planted, equivalent to 80% of the planned planting area. The remainder was left unplanted in order to allow for an adequate test of the machine planter when it is completed. Within a four days after planting, most of the cuttings appeared to be sprouting and weed control was largely successful except for a few missed areas. Planting success will be determined in the fall when survival and first season growth will be assessed.

*M7-Tree Harvester Testing:* These tests may be delayed due to additional time spent on the slip planter.

*M8-Post-planting Tending and Monitoring:* A neighboring farmer has been hired to monitor the site for weed control problems and/or insect damage problems. Project personnel will begin communicating with this individual on a weekly basis. Preliminary plans have been made for evaluating the survival and growth of the planting in the fall.

***Project Status:***

The project is on target with respect to components that impact the ability to meet future year milestones, i.e. the land was rented, the cuttings were obtained, and planting was completed at a scale sufficiently large for economic evaluations of planting, tending, and harvest costs.

The delay of completion of the planter is due primarily to inherent personnel constraints including the lack of available overload personnel and design changes that have been necessary to compliment the fabrication capabilities of the area machine shops. Many machine shops with precision computer controlled machine capacity have quoted lead times of more than 4 weeks. As a result, parts have been produced on manual machines and have often been delivered out of spec requiring re-machining and longer lead-times. Meeting the deadline for getting the new planter fully designed, tested and built prior to spring planting proved not to be possible given the design and fabrication challenge and the late date of contract finalization.

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