EnergyPerformanceSystems, Inc.

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

Contract Number: RD-50 Milestone: 7 Report Date: 2/7/2008

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Congressional District: 3 (Corporate Office; Rogers, MN)
Congressional District: 7 (Farm Location; Graceville, MN)
Congressional District: 6 (Equipment Building Location; Big Lake, MN)

MILESTONE 7 – SUMMARY REPORT
Tree Harvester Testing

Executive Summary:
The patented EPS Whole Tree Harvester™ described herein is designed to continuously move forward at 6 mph (8 ft/s) while cutting and accumulating trees grown in long straight rows on relatively flat ground. When a full load of trees (30 tons) is accumulated on the harvester, the trees are off-loaded onto a trailer. Overall the tree harvester is 52 ft long, 28 ft tall and 16 ft wide, and weighs 45 tons unloaded. The sub-systems of the harvester are: 1) frame and tracks, 2) power and hydraulics, 3) cutting head, 4) cab and controls, and 5) tree accumulator and unloading mechanism.

For the harvester tests one of the 400 hp diesel engines and two hydraulic pumps were connected via closed loop to two hydraulic motors, one in each of the tracks. The tracks were tested successfully over a range of speeds. The assembled harvester was jacked off the ground and the rear tracks were powered to a linear speed of approximately 6 ft/s. The hydraulically powered disk brakes on the rear tracks were activated and released to allow the forward and reverse motion of each of 28 ft long by 30 in. wide tracks. Starting, running and stopping the tracks were repeated numerous times. The diesel engine, hydraulic pumps, hydraulic motors with high and low speed shifting, and rear tracks and track brakes are fully operational.

Technical Progress:
7a. Completion of harvester testing

The patented EPS Whole Tree Harvester™ will be described prior to the testing of the harvester for a more complete understanding of the harvester.

Description of the Tree Harvester

The harvester is designed to continuously move forward cutting and accumulating trees grown in long straight rows on relatively flat ground. When a full load of trees (30 tons) is accumulated, the trees are off-loaded onto a trailer. The harvester is self-propelled and operates on four tracks that distribute the load on the soil to less than 11 psi. The sub-systems of the harvester are: 1) frame, skid pan and tracks, 2) power and hydraulics, 3) cab and controls, 4) cutting head, and 5) tree accumulator and unloading mechanisms. Overall the harvester is 52 ft long, 28 ft tall and 16 ft wide, and weighs 45 tons unloaded. The harvester is designed to handle trees up to 30 in. diameter and 120 feet tall. Minnesota tree farms typically have trees from 6 in. to 15 in. in diameter. The harvester is designed to travel up to 6 mph (8 ft/s) in the field and 12 mph unloaded on a road.

A pair of front tracks and a pair of rear tracks supports the steel frame of the harvester. The belted rubber tracks are each 30 in. wide and 13 ft long end to end from the rear drive to driven wheels. Each one of the tracks is equipped with a 200 hp, two-speed hydraulic motor with disk brakes. The front-end parallel steering uses tie-rod-connected track carriages with hydraulic cylinder steering, and the rear end has a center pivot for skid steering. The front tracks pivot to allow a turning radius of +/-15 degrees. The other sub-systems are mounted to the frame. The harvester body consists of six major sub-sections: the right side of the tree accumulator with the car bodies, chain drives and rail; the center skid-pan and harvesting head; the left side of the accumulator with chain drive unloading rails with phase shifter and motor drives; the diesel engines and hydraulics; the front tracks and struts; and the cab with operator seat and automatic controls.

Two 400 hp Caterpillar diesel engines power the 7 hydraulic pumps that drive the 10 hydraulic motors and 8 hydraulic cylinders and associated auxiliaries. One engine powers two 200 hp closed loop hydraulic pump-motors that drive the rear tracks and two open loop pumps that drive small motors and auxiliaries. The other engine powers three 200 hp closed loop hydraulic pumps that in turn power two front track motors and four smaller accumulator drive motors.

The cutting head consists of two horizontal 49 in. diameter blades mounted to a U-shaped 12 in. square box beam at the front of the harvester and two pre cutting wheels of 30 in. diameter mounted ahead of the larger circular cutting blades. The cutting blades are bolted to shaft hubs with shafts that are mounted in the box beam with two 7 in. diameter taper bearings.

A GE Fanuc Computer (logic controller) controls the two diesel engines, the four track motors, the hydraulic pumps, the tree accumulator paddles, suspension adjustment for slope of the ground, and end gate off-loading

The tree accumulator section uses pairs of paddles that capture, convey and accumulate the trees on the harvester.

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For transport the harvester can be disassembled into five sections: 1) rear tracks, axels, engines, pumps and associated structural frame; 2) skid pan, cutting head and blades, head hydraulic cylinders, and associated structural support; 3) right side of accumulator with paddles and chain drives, hydraulic oil tank with drain, supply and return lines, filters and valves; 4) left side of accumulator with unloading chains and drives, and 5) front tracks, struts, steering cylinders, and operator cab with control system. These sections are bolted together by 11 major 1 in. thick flanges and can be assembled and disassembled in the field.

Harvester Testing:

The harvester tests were run at Whirl-Air-Flow Co. in Big Lake, MN (see Figure 1 below). The hydraulic system was filled with 165 gallons of hydraulic fluid, and the harvester was jacked off the ground. The diesel engine was run at low rpm. The two rear track drive hydraulic pumps were connected to the diesel engine though a triple output step-up transmission with a 0.76 gear ratio. The pumps and track drive hydraulic motors were pressurized to approximately1000 psi. No leaks occurred. The hydraulically powered disk brakes on the rear tracks were released and the tracks readied for operation. (On hydraulic failure the disc brakes tighten with 50,000 pounds of stopping force.) The diesel engine was started and after sufficient air purging had taken place with the pumps in neutral, the tracks were controlled to their first operation at minimum speed. They were cycled to both forward and reverse while being inspected for proper tracking and operation. The tracks were then accelerated to a speed of approximately 6 ft/s. Starting, running and stopping the tracks were repeated several times. The tracks were run individually and as a pair, and the motors were run at both the low-speed and high-speed settings. The engine speed was controlled mechanically and track motor speed was controlled electronically. Starting, running and stopping the tracks were repeated numerous times. The diesel engine, hydraulic pumps, hydraulic motors with high and low speed shifting, and rear tracks and track brakes are fully operational.

Figure 1. EPS Tree Harvester showing rear tracks and diesel engine (yellow).

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Additional Milestones Completed:
M1 – Annual Land Rental (first year); report submitted April 2006, payment made.
M2 – Design & Test Planter Injection system; report submitted July 2006, payment made.
M3 – Tree Slip Purchase & Tractor Purchase; report submitted April 2006, payment made based on lease assumption.
M4 – Basic Planter Design and Fabrication; report submitted 12/6/06, payment made
M5 – Test Planter; report submitted 12/7/06, payment made.
M6 – First 80 acre Planting; revised report submitted 12/6/06, payment made
M8 – Post Planting Tending and Monitoring; report submitted March 2007, payment made.
M9 - Annual Land Rental (second year), report submitted July 2007, payment made.
M10-Tree Slip Purchase for Second Year and Tractor Rental: report submitted March 2007, payment made.
M11 – Completion of Purchase of Automatic Position Control for Planter and Completion of Update of design drawings, installation and testing: report submitted Sept. 2007, payment made.
M12 – Second 80 acre Planting and Commercial Spray Rig Modification; report submitted Sept. 2007, payment made.
M14 – Annual Tending and Monitoring of Trees; report submitted Dec. 2007, payment made.

Milestones In Progress:
M13 – Harvester Testing and Modifications; work on the harvester is progressing.

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