BIOMASS POWER FOR RURAL DEVELOPMENT

DOE/GO/10132--T3

TECHNICAL PROGRESS REPORT

Contractual Reporting Period
January 1 - March 31, 1998

PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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General Public Utilities (GPU)
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Cornell University College of Agriculture & Biological Engineering
Cornell University Laboratory of Ornithology
University of Toronto
New York Gas Group (NYGAS)
South Central New York RC&D
New York State Energy Research and Development Authority (NYSERDA)
Gas Research Institute (GRI)

November 1998

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1.2 Revised Schedule of Deliverables

Deliverable	Original Due Date	Revised Delivery Date
Design Reports		
Greenidge -	February 1997	Delivered
Dunkirk -	July 1997	2nd Quarter 1998
Fuel Supply & Site Development Plans		
Greenidge -	January 1997	Delivered
Dunkirk -	July 1997	Delivered

2.0 PROGRESS SUMMARY

During the first quarter of 1998, the Consortium continued to work with DOE on preparing a contract for the Phase-II effort. The first quarter of 1998 feedstock development activities were dominated by pre-planting activity in the spring and finalizing plans for retrofit activity at Dunkirk Station in the 3rd and 4th quarters.

This report represents the final report issued under the Phase-I contract. Any final reports or issues that remain to be addressed will be noted in the Phase-II progress reports. The first progress report in Phase-II covering the second quarter of 1998 is expected to be released in late August or early September.

Fuel Supply Development

- The Dunkirk fuel supply plan was completed during this reporting period.
- Numerous site visits were made throughout New York to identify additional land for planting in the Spring.

Power Conversion Technology Development

- Dunkirk retrofit design completed and undergoing review
- BED facility gasifies wood for the first time

Enterprise Development & Outreach

- A proposal was completed requesting an exemption for planting willow biomass crops on Conservation Reserve Program (CRP) land.
- Abstracts were prepared and submitted for the October Bioenergy '98 Conference in Wisconsin.

3.0 DETAILED TASK PROGRESS REPORTS

3.1 Task 1. Design Packages

During this reporting period, NMPC finalized the designs for the retrofits at Dunkirk Station and scheduled an outside design review. NMPC has already requested bids from equipment suppliers to supply the hardware for the retrofit. Once the outside design review is completed, NMPC will begin placing orders for equipment. Full details of the system design will be presented in the Design Report which will be released in the 2nd quarter of 1998.

3.2 *Task 2. Fuel Supply and Site Development Plans*

A fuel supply plan for Greenidge and Dunkirk Stations have been completed and submitted. Each of these plans outlines estimates for willow fuel supplies for cofiring in the stations during Phase-II. The plans also outline biomass residue supplies that will be used to initiate cofiring at these facilities until willow feedstock is available.

3.3 Task 3. Major Equipment Guarantees and Project Risk Sharing

The Consortium partners continued to explore additional equipment options for the planting and harvesting equipment that will be used in Phase-II. Plans were finalized to purchase a STEP planter from Salix Maskiner (Sweden) for use in 1999 planting activity.

3.4 Task 4. Power Production Commitment

NYSEG has already begun producing power at the 5% to 10% cofiring level using residue supplies. In effect, its commitment to power generation from biomass has already been demonstrated. NMPC will not cofire on a continuous basis until the 4th quarter of 1998, but retrofit plans are on track, and NMPC has made a corporate commitment to pursue biomass cofiring.

The gasifier at Burlington Electric Departments McNeil first produced gas from wood on February 21, 1998. The wood specifications remain stringent, but the Consortium is hopeful that willow can be gasified at the facility late in 1998.

3.5 Task 5. Power Plant Site Plan, Construction & Environmental Permits Report

Site plans for the co-firing retrofit of Greenidge were prepared by NYSEG and will be revised pending location of the day bin and expanded yard area for receiving biomass fuel supplies. Environmental permits for cofiring biomass at Greenidge are already in place. Emissions monitoring has already begun with the test program and preliminary air emissions results are available. Sulfur dioxide reductions have been quantified, and NO_X reductions have been measured under certain feedstock and firing conditions. A report is being prepared with the Electric Power Research Institute (EPRI) that will characterize the performance of the biomass fuel ramp-up tests.

NMPC is still in the process of evaluating potential issues for permitting a cofiring project at the Dunkirk site including potential impacts on its ash sales.

3.6 Task 6. Experimental Strategies for System Evaluation

Cutting production was completed at the NYS Department of Environmental Conservation Saratoga Tree Nursery late in the month. Final production will be available soon. These figures, in combination with those from SUNY-ESF, will facilitate the development of precise planting designs for the 1998 scale-up acreage.

Feedstock Development Efforts

Site visits were made with two landowners in Western New York and one in central New York. The total land area inspected was approximately 70 ha (173 acres). The central New York site was unacceptable because slopes exceeded 8 percent. In western New York, one owner was concerned with the use of herbicides. The other owner would like to see how well the willows grow in the 1998 plantings at the Sheridan and Leon sites before committing to the project.

A site visit was completed on several other parcels of land totaling 100 acres in Truxton, NY. Sites were not suitable because they were too steep, inaccessible, or excessively wet. Because of difficulties in finding rental properties in the central NY area that are suitable for growing willow, SUNY-ESF has taken out an advertisement in a local newspaper and notified several real estate agents of our desire to rent land.

SUNY-ESF staff met with a landowner in Canastota who has several hundred acres of tillable land. Most of the land was used to grow corn or hay during 1997. Negotiations to rent approximately 20 acres for planting this year are ongoing.

Cutting production for the 1998 planting season was nearly completed at the Genetics Field Station in Tully, NY. Over 250,000 cuttings were made from cutting orchards at Tully. Native willows were left standing for the collection of materials for breeding work and will be harvested at a later date. Shoots of some willow clones were cut into "whips" 1.5 m (5 ft) in length for use in a Swedish step planter.

Willow cutting production was completed at NYDEC's Saratoga Tree Nursery and in SUNY-ESF's cutting orchards. The total number of cuttings produced in 1997-98 exceeded 870,000. Sufficient numbers of cuttings were produced to meet 1998 planting needs, but production was lower than anticipated. Cutting production averaged 15 cuttings per stool at Tully and Saratoga. Lower than anticipated production in the SUNY-ESF cutting orchards is likely due to reduced fertilizer application during 1997 compared with previous years. At Saratoga, the irrigation system was shut off when willows grew above the level of the irrigation risers, which was only 30 cm. Precipitation was well below normal after irrigation was shut off in 1997 so the trees were unable to achieve full growth potential. More systematic fertilizer

applications over the growing season at Tully and modifications to the Saratoga irrigation system should boost cutting production in 1998. Beds of non-commercial willow clones at Saratoga will be removed and replaced with more productive ones.

Arrangements were finalized for shipping cuttings from Saratoga to western New York for spring planting. A refrigerated storage trailer will be kept at the Niagara Mohawk Power Corporation's Dunkirk power plant for the duration of the planting season. A student field crew has been hired for planting season.

A meeting was held in Jamestown, NY, to discuss the roles of SUNY-ESF, FORECON, and South Central NY RC&D in the willow plantings scheduled for this spring and coming years in western New York. Important points made in that meeting included:

- Weeds need to be controlled during the establishment year. All sites will be double disked prior to planting and a pre-emergent herbicide applied after planting. SUNY-ESF in conjunction with FORECON will monitor the fields on a regular basis to identify any weed or other pest problems. FORECON will be responsible for completing weed control operations, if needed.

- Detailed field maps are needed to plan the specific field designs. After field mapping, a priority order for planting the various fields will be made.

- The need for rock removal in sites planted in 1998 will be assessed following spring disking.

- SUNY-ESF will investigate if there are any herbicides that cannot be used in the vicinity of grapes, or any pesticides used on grapes that would be harmful to willow.

- FORECON will be responsible for coppicing in the fall/winter of 1998/99. SUNY-ESF will loan FORECON equipment once coppicing is complete in the Syracuse area.

Two Frobbesta planting machines purchased from Sweden were shipped to the U.S. The planters were sent to Cornell University in Ithaca, NY, where modifications will be made by the Department of Agricultural and Biological Engineering.

Clone-Site Testing/Genetic Studies

Statistical analyses were completed on biomass measurements completed during November 1997 in the clone site trial at Massena, NY. Trees were harvested on a four-year cycle, rather than a three-year cycle, due to severe deer browse damage. Significant differences among clones ($p = 0.008$) were observed for biomass production. Highest production was by willow clone SV1, averaging 36.9 odt ha-1 (9.2 odt ha-1 yr-1). Large variability observed for willow clone SV1 was due to severe deer browse damage that occurred in one of the three replications during 1995. In

both the Massena and Tully trials, willow clones SV1, S365, and S301 were ranked first, second and third for biomass production, respectively. Average annual production of the clones planted at both locations was nearly identical (8.9 and 9.2 odt ha-1 yr-1 at Tully and Massena, respectively).

Biomass data collected for first year growth in the clone-site trial at Burlington, VT were statistically analyzed. Six willow clones and one poplar clone were planted on this site. Statistically significant differences among clones ($p= 0.019$) were observed. Hybrid poplar clone NM6 had the highest biomass production (1.03 odt ha-1) of the seven clones.

Laboratory analyses of foliage and soil samples collected during 1997 in fertilizer rate studies at Tully, King Ferry, and Somerset, NY, continued. A new analysis of biomass regression equations based on measurements completed during 1996 was nearly completed. Measurements will be completed during January 1998 for refining these equations.

Willow breeding efforts continued. Shoots were collected from nine male S. eriocephala, four S. purpurea, two S. udensis, and one S. discolor clones and placed in a greenhouse in water. Flowers of some clones began shedding pollen as quickly as three weeks after collection. Flowers were harvested, flooded with carbon tetrachloride to extract and wash the pollen, and pollen was frozen at -20 °C. Pollen collection will continue during February, and shoots from female willows will be brought into a greenhouse to force the flowers in preparation for controlled pollination.

Pollen collection was completed during early February from all male willow clones planned for use in breeding experiments. Pollen yields from most clones were sufficient to enable completion of all planned crosses. Notable exceptions were clones S365 and S301 that did not yield pollen. Shoots from females bearing flower buds were collected in the field and brought into a greenhouse and placed in water during early February. Controlled pollinations began during mid-February. The majority of controlled pollinations planned for winter 1997-1998 were completed. Seed shed is expected during mid- to late-March 1998. Many of the species combinations attempted in the interspecific hybridization study have never been done previously. Viability of all the pollen used in controlled crosses will be tested to ensure that if a cross fails to yield viable seed, the possibility of unviable pollen as the cause of the failure can be eliminated. Most of the pollen samples were used in more than one cross, which will serve as an additional check on pollen viability.

Willow cuttings from eight clones (twenty cuttings per clone) were sent to the Long Ashton Research Station (U.K.) for use in their breeding program. The clones included SV1, SH3, SA2, S546, S301, S365, SX64, and PUR12.

Laboratory analysis of 1997 foliar tissue and soil samples for the fertilizer rate studies imposed over the willow clone-site trials at Tully, King Ferry, and Somerset, NY continued. Stems were measured and collected in January 1998 for expansion of the biomass equations; oven-dry

weights were recorded and will be incorporated into the biomass equation database, followed by development and selection of improved biomass equations. Diameter measurements of trees in their second year of the first rotation in the willow demonstration area at Tully, NY began.

A genetic selection trial was established at Tully during spring 1997. A companion study was established at the same time in cooperation with the USDA Forest Service in Rhinelander, WI. Thirty three willow and seven hybrid poplar clones were planted in four replications with 48-tree plots. Data collected during summer and fall 1997 on seasonal variation in leaf area were evaluated. A rapid increase in willow leaf area of willows after the second week of August was observed. Willow clone S365 had the highest maximum mean leaf area (0.53 m2). Specific leaf weight (leaf weight/leaf area), an indirect measure of leaf thickness, increased during the growing season. There were two periods of large increase in specific leaf weight, one during the beginning of August, and the other during the middle of September. These increases correspond to times of drought. The extent of change may be indicative of a clone's adaptability to moisture stress.

Leaf area ratio (leaf area/total above-ground dry weight) and leaf weight ratio (dry leaf weight/ total above-ground dry weight) decreased over the season. Foliage comprised 45% to 75% of above-ground biomass (by weight) early in the growing season. The leaf weight ratio decreased as the season progressed due to increasing stem and branch biomass. At the end of season, the leaves comprised only 25-45 percent of the above-ground biomass.

Plans for April 1998

Planting will begin as soon as site conditions permit. Sites that will be planted include Easton, Pennsylvania (0.8 ha clone-site trial), Lafayette, NY (1.6 ha demonstration area), Leon, NY (15 ha and a 0.6 ha clone-site trial), Saratoga, NY (0.6 ha cutting orchard), Sheridan, NY (a 0.6 ha clone-site trial and a 7.5 ha demonstration area on one site, and a 19 ha demonstration area on a nearby site), Wolcott, NY (0.6 ha clone-site trial and a 2.0 ha demonstration area), and Lincoln, NY (8 ha demonstration area). Sites will be disked prior to machine planting.

3.7 Outreach, Extension, & Technology Transfer

Numerous outreach, extension, and technology transfer events also occurred during the 3rd quarter. A highlight of these events is provided below.

- A proposal was completed by SUNY ESF and South Central New York RC&D staff requesting an exemption for planting willow biomass crops on Conservation Reserve Program (CRP) land in 12 counties across New York. The statewide Farm Services Agency (FSA) committee met in late January to consider the proposal. If accepted, CRP land could be available for the 1999 planting season.

- An invited presentation was made at the Indiana Arborists Association meeting in

Indianapolis (January 12-15). Two posters on the willow biomass program were presented at the New York Society of American Forester's (SAF) meeting held in Syracuse, NY (January 28 - 30).

- A meeting of members of the Salix Consortium was held in Syracuse on January 27. Members updated each other on program progress and ongoing work. Discussions were held on coordinating efforts for the upcoming planting season. Steps are being taken to organize more detailed planning sessions with SUNY ESF, FORECON, and the South Central New York RC&D.

- A feature article entitled "Future Fuel: Niagara Mohawk Experiments with Willow Wood as Fuel Source" appeared in the January 25 edition of the Sunday Observer in Dunkirk, NY. A group of about 20 students who are studying agroforestry at Cornell University toured the SUNY-ESF willow biomass plots in Tully, NY. The group was particularly interested in learning about the production system for willow biomass crops and how it might be modified for agroforestry systems in the Northeast.

- Abstracts were prepared and submitted for the Bioenergy '98 Conference in Wisconsin in October entitled "The Salix Consortium - A Partnership for Bioenergy Commercialization," "First Year Growth and Development of Willow and Poplar Tree Crops as Related to Photosynthetic Leaf Area and Duration," and "Economic and Business Model of a Commercial Willow Energy Crop." An abstract was submitted for the Short Rotation Woody Crops working group meeting in Washington, DC, August 1998, entitled "Producing Short Rotation Willow Crops in the Northeastern United States."

- Input was provided for two different proposals that drew upon the knowledge and expertise of a wide range of individuals and organizations. The first was submitted to the Environmental Protection Agency (EPA) by SUNY-ESF. The goal of this project is to determine the effectiveness of willows as a phytoremediation agent on polycyclic aromatic hydrocarbons contaminated dredge spoils. The second was a Small Business Innovative Research (SBIR) proposal submitted to the DOE by Highland Graphics and FORECON. The thrust of this proposal was to develop a GIS system to improve the management of willows biomass crops.

- A presentation about the willow biomass program was made to staff at Lafayette College in Easton, PA. Following the meeting, a site visit was made to examine land the college has made available for a willow clone-site trial. The area will also serve as a demonstration area for outreach and education efforts. Final arrangements for site preparation were completed with farmers who have rented the land in recent years. This clone-site trial is the first of three in Pennsylvania that are planned over the next two years. On March 27th, collaborators from Pennsylvania came to Tully, NY, to tour the willow biomass trials and learn more about establishing willow biomass crops. This

research is a cooperative effort of SUNY-ESF, Lafayette College, GPU Energy, US Forest Service State and Private Forestry, and the Coalition of Northeast Governors.

- The Farm Services Agency (FSA) statewide committee approved a proposal to plant willow biomass crops on Conservation Reserve Program land in twelve counties across New York State. The proposal was forwarded to FSA staff at the Federal level for final approval.

- SUNY-ESF collaborated with ANTARES and NMPC to write a proposal related to small modular power generation plants. SUNY-ESF's portion of the project focuses on resource assessments for a variety of biomass feedstocks including short-rotation willow, forest thinnings, residues from the wood products industry, and animal manure. The proposal was submitted to Sandia National Laboratory for funding.

- SOCNY RC&D has begun to survey institutions in New York which have combustion permits from Department Electric Congregation. This information will be used to write a report on the potential supplemental facility heating market for willow biomass in New York. A preliminary report will be finished by the end of the 4th quarter of 1998. Institutions being investigated include college and university campuses, public schools, prisons, manufacturing plants, greenhouses, and others.

APPENDIX A

SWEDEN TRIP REPORT

REPORT TO SALIX CONSORTIUM
Sweden Trip
Februrary 27 - March 6, 1998
Equipment Field Tour
Biomass Harvesting and Planting Equipment

TO: Salix Consortium

From: Larry Abrahamson, SUNY ESF
Roger Pellerin, Cornell Ag. & Bio. Engr.
Dan Aneshansley, Cornell Ag. & Bio. Engr.

Re: Evaluation of Austoft, Salix Maskiner Bender (Red), and Claas Jaguar Salix Harvesters.

Summary:

If the Salix Consortium can't find a cooperator in Claas, Austolf or some other harvester manufacture, then it is our recommendation that the Bender would be an excellent choice given our varied harvesting requirements. The power plant for the Bender could easily be American made as well.

The Austoft 7700 Salix Harvester (converted sugarcane harvester), the Salix Maskiner AB Bender (Red), and the Claas Jaguar 695 harvester were all observed harvesting Salix. We also discussed the performance of these machines with Birger Danfors of the Swedish Institute of Agricultural Engineering and obtained a report on their performance (see attached).

These machines are predicted to harvest between 1250,900 and 1750 acres per year (assuming 1000 hours or 100-120 days of operation per harvest season). Thus any of them have the capacity to handle the harvesting needs of this project.

The quality of the chip was adequate and appeared to be adjustable or selectable from 1 to 2 1/2 inches for all machines. The Austoft is capable to cut 1 1/2 to 8 inches. The Class had some stringy parts (length wise cuts as opposed to radial cuts).

The cut on the trees was acceptable except for the modified blades being used by the Austoft. These blades produced stumps that were split and ragged (prone to disease). Saw blades similar as that used by the Claas could be used on the Austoft to improve the stump cuts. Blades for the Austolf and Claas are more expensive ($200-250) while the flying chain on the Bender was less expensive($60-80) but needed more maintenance.

The Claas and Austolf are self powered machines while the Bender is attached to a tractor front PTO. Therefore, the costs are much greater for the Claas and Austolf. The Bender is much more portable as only the cutter and chipper head must be

transported. This could be a real advantage for this project depending on the number of harvesting locations and distance between them.

Introduction:

Larry Abrahamson, SUNY ESF, Roger Pellerin, Cornell Ag. & Bio. Engr. and Dan Aneshansley, Cornell Ag. & Bio. Engr., spent 5 days in Sweden (Sun Mar. 1 to Thurs Mar. 5) visiting field sites where Austoft, Bender and Claas Salix harvesters were being used to harvest Salix. We also spent a day at the Swedish Institute of Agricultural Sciences in the Department of Short Rotation

Table 1 and 2 summarize some of the characteristics of the harvesting system. Table 1 contains the comments of the individuals visited while Table 2 is a summary of the information contained in the Biger Danfors paper "Latest Data on the Harvesting of Energy Forest in Sweden" (1996)

SITES VISITS:

Austoft - Henrikssons Salix AB

Annika and Gunard Henriksson of Gudmundtorp, St. Beddinge 231 98 Klagstorp, Sweden (Tele. +46 410 256 15) demonstrated the Austoft Model 7700 modified sugarcane harvester.

The Austoft harvester with crawler tracks can operate during soft field conditions. The machine is shipped between countries to harvest Salix crops in Sweden, Denmark, Italy and Germany. The transport of the harvester between small fields one to two miles apart would be costly. We observed a ragged quality of stump cut during our demonstration. The splitting and ragged cut would not be accepted for New York. The blades used during the demonstration were modified flat plate that was filed to form a cutting notch. The notch was sharpen daily. This modified blade allowed for ease in resharpening and repair especially in stony conditions. The increase cutting length from 1 1/2 to 8 inch billets would increase harvesting rate and efficiency. The preliminary reaction is the harvester is large and complex machine for a single use and limited harvesting season.

Field Notes:

Harvester Capability

Austoft sugarcane harvester converted to Salix harvester.

- Removed blower fans
- Repositioned cutting blades from rear angular position to a horizontal forward position. This required an additional horizontal feed roll and improved snow removal during transfer to rear chipper unit.

  Note: Mr. Henriksson would not recommend this change in future machine. The changes were not beneficial in machine performance.

Harvesting Rate

- 1 Hectare per hour (2.47 acres per hectare)
- Cutting length 1 to 1-1/4 inch billets (potential range 1 to 8 inches)
- Cutting height 3-4" above ground
- Cuttings are 750 mm (30")between rows and 500 mm (20") within the row and 125 cm (49") between two row configuration

Note: This spacing results in wide rows after 1-3 harvests due to branching - A 3 meter (10 ft) single row would result in a more balanced row.

- 1 set of blades per 100 hectares (250 acres)
- Sharpen the blades every day
- 1/2 hour to change blades
- 1500 SEK (~$200) per blade (farmer is charged for any blade damage caused by rocks)
- Original saw blades used for sugar cane harvesting resulted in split and ragged cuts.
- Machine harvest 500 hectares (1250 acres) per year (capable of 1000 hectares -2500 acres per year)
- Row length 400 to 500 meters (1312-1640 feet) maximum
- Harvester 240-350 HP
- Fuel consumption 30 - 40 liters/ hr (8-10 gal/hr)

Transport

- 25 cubic meter (883 cuft) tractor towed tipping wagon
- 70 SEK per cubic meter (~ $219 per load)

Planter

- 8-10 inch billets in a shallow **single row** planter

Bender - Salix Maskiner AB

Ragnar Wilstrand (father), Mats Wilstrand (son), Hamre 1, S-776 90 Hedemora, Sweden (Tel. ++46 225 711630) demonstrated the latest model of the Bender (red) in the field and the step planter in their machine shop.

The Bender harvester is a tractor mounted cutting and chipper unit with a towed two wheel wagon. The prime mover is a 4-wheel drive leased tractor. The harvesting unit can be mounted on a 200 HP wheel or track mounted tractor. The tandem mounted harvester and trailing wagon aids in setting up harvesting layout. Delays in harvesting occur with the need to transport the wagon to a holding area and unload the wagon. The Bender with high chipping head and unique tree handling system (bending the tree at mid point into the chipper) results in minimum snow pickup. The simplicity and flexibility of the machine makes ideal for small acreage plantings. The harvester could be driven to multiple fields within a mile or two.

Field Notes:

Harvester Capability

Bender 1998

- latest model (red model)

- 4- 5 year development

Harvesting Rate
- 3 hours per hectare (0.82 acres per hour)
- 1-1.5 inch chips (change in length range is not clear)
- 4 blade chipper
- Flying chain (heavy duty chain saw blade)
- Replace chain every 4 hours (resharpen 170 SEK ($21.25) per chain)
- Breakaway chain links cost per chain 400 SEK ($50)
- Tractor power unit IH 7120 (180 -210 HP)
- Tractor front PTO dual drive operates hydraulic pump and feed mechanism
- Hydraulic pump 150 l/min (40 gal/min)
- Vegetable oil hydraulic fluid (Environmental compatible)
- Oil temperature hot (the unit needs an additional oil cooler)
- Machine harvested 60 hectares 1997-98

Transport
- Harvester towed 8 cubic meter (280 cu ft) tilt wagon

Step planter

The automatic step planter requires two operators, a tractor operator and planter feed operator. The planter has two auto feed mechanism. A sloped slide trough and a revolver feed unit. The new revolver feed mechanism is the recommend feed mechanism. A potential for jams occurs during the transition of whips . When feeding a new whip the insertion of the but end of the new whip slips passes the tapered end of the previous planting whip. Planting whips should be straight with a minimum tip diameter of 1/4 inch in order to reduce jams. The planter has the capability for multiple adjustment in planting spacing such as; within the row between rows and staggered plantings. The double row spacing between rows can be adjusted by changing the mounting positions of the four planting rows.

The planter was demonstrated in the machine shop, using a portable hydraulic feed drive to simulate slow action operation. Video of the various components were recorded to further evaluate its operation. The planter is well designed and requires some understanding of its kinematics in order to fully utilize its flexibility. With minimum training the planter should be adaptable to our needs in New York planting needs.

Field Notes:
Bender - Step Planter
Salix Maskiner AB
Mats Wilstrand
Managing Director
S-776 90 Hedemora
Sweden
Tel: +46 225 711630

Planter Capability

Step Planter (Red Machine)

- Four row whip planter
- Whip length 140 cm (55 inches)
- Cutting length 160-300 mm (6-24 inches)
- Linear speed 3.6 KPH (2.3 MPH)
- Planting rate 1 hectare per hr (2.46 acres per hour)
- Planting adjustments
    - Within the row spacing - PTO RPM, tractor speed, and variable speed friction drive
    - Alternate twin row spacing
    - Cutting length
    - Adjustable row width
- Tractor 70 HP 4 wheel drive (The planter weight distribution requires 4 wheel drive or front wheel drive)
- Tractor with PTO - 540 or 1000 RPM
- Class 2 - 3 point hitch
- Coulter hydraulic control
- Patent (International Salix Machinery Vilstrand Mekaiska AB)
- Hydraulic connections - British straight pipe thread (BSP)

Claas Jaguar Agrobransle (Cooperative)

Gustav Melin (Managing Director) and Goran Sjostrom, Box 1743 SE-701 17 Orebro, Sweden (Tel. +46 19 21 78 80) had the Class Jaguar demonstrated for us.

The Claas Jaguar harvester is a multi use machine. The harvester can be used as a forage, corn or Salix harvester by merely changing the pickup heads. The latest designed cutting head for Salix harvester was demonstrated. The new design accommodates deep snow conditions by allowing the snow to drop out of the feed line before chipping. The pickup head has two horizontally mounted carbide tooth circular saws to cut the trees and a spike wheel feed mechanism that maintains the tree upright onto the horizontal feed rollers that that direct the butt end first into the chipper. The saw blades are vulnerable to field stone conditions. The saw blade repair cost due to stone damage would be the greatest for the Claas machine. However, the Claas produced the best butt cuts. The Claas harvester could easily travel over the road to nearby fields 1 to 2 miles apart. Frozen ground conditions or well drained soil is required to support the harvester. In a recent Resource magazine March 1998, published by ASAE, the Claas, Caterpillar manufacture have combined forces on a special harvester project. The potential of there interest in willow harvesting should be explored.

Field Notes:
Harvester Capability

Claas Jaguar

- New modified head (Feed spike drive and increased feed rolls to shake off snow collection)
- 1- 4 hours per hectare (0.6 to 2.45 acres / hr)
- 3-8 kilometers per hour (2-5 mph)
- Harvest per machine - 300 hectare / yr(750 acres /yr)
- Total of 1400 hectare (3500 acres / yr) total 3 harvesters
- 1 Claas 1.7 million SEK (~$212,500) Had to purchase 6 units in order to get development support from Claas

- 1 saw blade per 10 hectares (25 acres)
- Sharpen 3 times per year
- Cost 2000 SEK ($250) per blade

Transport

- 25 cubic meter (838 cu ft) towed wagon
- 33 tons per 25 min

Planter

- 7500 SEK ($380/acre) per hectare
- Subsidy 3300 SEK ($165/ acre) per hectare

Department of Short Rotation Forestry

We spent the last day of our visit at the Department of Short Rotation Forestry in the Swedish University of Agricultural Sciences in Uppsala.

Prof. Lars Christersson describe Sweden's use of Willow and other energy crops in meeting the energy demands of Sweden.

Prof. K.L. Perttu described projects which use Salix as vegetation filters for purification of waters and soils.

Prof. Theo Verwijst described his work on plant spacing, rotational length and clonal composition.

Prof. Danfors described some of his work on the harvesting machines used in Sweden. (Pellerin and Aneshansley shared some of the efforts on planters with Dr. Danfors.)

Prof. Abrahamson described his and the Salix Consortium's efforts in the US.

Publications:

1993-1997 List of publication from Department of Short Rotation Forestry. Swedish University of Agricultural Sciences Box 7016 s-750 07 Uppsala, Sweden. Fax: 46 18 673440 Tel: +46 18 672551

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TABLE 1 : Data collected from individuals at field demonstrations

	Harvest Rate		Vehicle	Fuel	Cutting Blade Cost	Sharpen	time/ sharp	Duration	Price
	acres/ hr	per year	HP	gal/hr	$	$		acres	
Austoft	2.5	1250	240-350	8-10	200		24 hrs	250	
Bender (Red)	0.83	830 est	180-310		50	21.25	4 hrs	?	$50-70K
Claas	.65-2.5	1750			250		3x/yr	25	$212K

Table 2 : Data provide by Prof. Danfor's paper.

	Weight	Power		Fuel		Harvesting Capacity		Cost*	
	(tons)	kW	hp	liter/ hr	gal/hr	ha/hr	acre/hr	SEK/kWh	$/kWh
Austoft 7700	12.5	175	235	30	7.9	0.50	1.25	0.0493	0.00616
Bender 125 kW	11.2*	125	168	25	6.5	0.36	0.90	0.0407	0.00508
Claas Jaguar 695	10.0	257	345	40	10.5	0.70	1.75	0.0367	0.00458

* 8 Swedish Krona = $1