# DENSIFICATION AND DEWATERING OF BIOMASS

ACRE Interim Report

prepared by

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**Work completed to date/relevant findings**

A literature review was conducted which examines technologies for biomass dewatering and densification. Biomass dewatering and densification related to cellulosic ethanol production is important for several reasons. First, dewatering of fresh biomass is important for handling and transportation to the biorefinery—transportation costs are reduced, the energy content is enhanced and the feedstock is preserved against microbial decomposition. Second, biomass dewatering is important in the biorefinery. For example, if biomass is pretreated to release soluble sugars for fermentation, efficient dewatering of solid residue and recovery of sugar containing solutions is necessary to maximize soluble sugar yield and to reduce water consumption during rinsing. The resulting solid residue, if burned for fuel, must be dewatered to increase combustion efficiency.

Additionally, a number of laboratory- and pilot-scale tests have been completed with biomass samples (pine chips, sugar cane bagasse) subjected to dewatering using a number of physical processes including several types of mechanical compression, vacuum filtration and centrifugation. Energy utilization and liquid extraction efficiencies have been determined for a number of biomass substrates.

**Progress toward expected outcomes**

We have completed a number of laboratory tests. A conventional mechanical dewatering screw press (Vincent Corp.) was used to dewater acid- and steam-pretreated sugar cane bagasse and pine wood chips to 48.1% and 58.9% moisture on a wet basis, respectively. These moisture contents are in line with expected outcomes (see next section). Further dewatering of this material in an Atlas shop press at an applied pressure of 40 tons (0.815 tonnes/cm$^2$ or 5.84 tons/in$^2$) lowered the moisture content of bagasse to 25.8% and pine wood chips to 30.8%. The latter value approaches what we consider the theoretical maximum for strictly mechanical dewatering of woody biomass: the fiber saturation point. This value is given in the literature as about 30% moisture (23% on a wet basis). We found centrifugation and vacuum distillation were not as effective as mechanical compression for biomass dewatering, as expected. A Mori grape press gave dewatering results with pine chips in line with the Vincent press—averaging 56.4%. Additional dewatering of biomass was achieved by combining the

Vincent press with the grape press. For example, bagasse moisture content was reduced to an average of 41.3% by the combined treatment.

As part of this project, we originally planned to pursue the production of a prototype triaxial press to improve biomass dewatering and densification. Although we have engineering data and costs for a triaxial press, we no longer favor this approach for several reasons. First, it would be difficult to convert a triaxial press to continuous operation. Second, our literature review and test work experience on this project indicate biomass moisture reduction and sugar extraction targets can be achieved by a combination of existing mechanical press technology and efficient countercurrent washing. Reduction of sugar cane bagasse moisture content by mechanical dewatering to that measured in our pilot scale testing would meet our target calorific values for combustion as a boiler fuel. Third, although we will include biomass densification in our literature review and discussion, our company emphasis is on biomass dewatering as a key aspect of our technological process.

**Preliminary findings and/or key accomplishments to date**

Moisture removal from biomass may be accomplished by heat or mechanical methods. Thermal drying can remove more moisture than mechanical compression, however, it slow and energy intensive. It is also not applicable to use in the biorefinery for recovery of sugar solutions.

A moisture content of 50% (wet basis) is commonly cited as the maximum achieved by rapid mechanical dewatering of biomass using currently available equipment. Dewatering of pasty or liquid solid waste by filter presses, belt presses and centrifuges produces residues still containing 60% to 80% moisture. A promising recent development is the combination of elevated temperature and high applied pressure to dewater biomass, known as mechanical thermal expression (MTE) or thermally assisted mechanical dewatering (TAMD). Elevated temperature reduces water viscosity, density and surface tension thereby increasing the permeability and rate of water removal from a material by compression. It appears a commercial machine (Bio-Gas Technologies, Lynnwood, WA) takes advantage of this principal to produce biomass containing 36% to 42% moisture. Friction from compression of biomass by a helically threaded auger screw shaft heats the material. Compressive force is applied through a variable compression nozzle.

We conducted pilot scale pretreatment tests with sugar cane bagasse in collaboration with Andritz, Inc. at their Ohio facility. A key component of this work was assessment of dewatering efficiency at ton-scale. Dewatering of hydrolyzed bagasse is important for efficient recovery of sugar-containing solutions for fermentation to ethanol. A model 560GS Impressafiner at a volumetric compression ratio of 8:1 was found to efficiently dewater bagasse at ton scale to produce material of 30% to 35% moisture. The extent of dewatering of hydrolyzed bagasse was surprisingly good and suggests this approach to dewatering pretreated biomass can yield close to the expected maximum amount of solution. If combined with a countercurrent rinse, good sugar extraction efficiency with a minimum amount of water may be possible.

### Problems encountered and/or mitigating circumstances

No special problems have been encountered to date on this project.

### Next steps

The next step is to combine our literature review and our laboratory testwork into a finished document discussing the merits of various methods for biomass dewatering in the context of the emerging biofuels industry. Commercially available equipment for dewatering of biomass will be discussed. The preferred process(es) will be identified in the context of our commercialization of biomass conversion into liquid fuels.

### Anticipated changes to project timeline

No changes in the project timeline are anticipated.