# TOWN OF ORRINGTON, MAINE

October 27, 2015

Maine Department of Environmental Protection
Division of Technical Service Solid Waste Management
Bureau of Remediation and Waste Management
Attention: David Burns, P.E., Project Manager
17 State House Station
Augusta, Maine 04333-0017

RE: Fiberight, LLC & MRC Project – DEP# S-022458-WK-A-N

Dear Mr. Burns:

On behalf of the selectmen and the residents/property owners of the Town of Orrington, I am submitting to the Maine Department of Environmental Protection the first in a series of inquires regarding the permit application of Fiberight, LLC and the Municipal Review Committee (MRC) for the proposed solid waste processing facility in Hampden. (Project number DEP# S-022458-WK-A-N). This initial submittal consists of an analysis of the University of Maine's Forest Bioproducts Research Institute (FBRI) that was contracted to conduct a peer review of the Fiberight technology to convert MSW to ethanol (so-called Trashanol), a biogas (methane via Anaerobic Digestion) and other by-products. The final FBRI report was prepared on January 30, 2015, and titled *Technology Review Fiberight Process for MSW* and is also found deep in the back of Attachment 13 of the 534 page Solid Waste Processing and Recycling Facility Permit Application.

Orrington has a number of citizens and property owners with chemical engineering, pulp and paper and/or enzymatic hydrolysis experience in producing quality industrial fermentable sugars from cellulose. Thus, Orrington is uniquely positioned to respond at a technical level to the proposed Fiberight facility and has prepared the attached document that critiques both the technology and the FBRI study. It is also positioned to know first hand, the years of environmentally sound and professional services that the Penobscot Energy Recovery Company, LP (PERC) located in the town of Orrington has provided to the municipalities that have contracts to deliver their solid waste to PERC for many decades.

Our experts have noted a number of deficiencies in the FBRI analysis and/or the MRCs' response to deficiencies noted by the FBRI team. For example, no Fiberight testing has been done on the critically important Anaerobic Digestion process equipment produced by Hydrothanes' Expanded Granular Bed system at a commercial scale, yet FBRI does not alert the MRC to the risk of a failed

project in Hampden. In other cases, the FBRI notes areas of limited data, limited pilot scale or commercial scale operation for the overall process, while stating that the individual process units are similar to those used in the pulp and paper industry. Yet the FBRI staff does not clearly state that the efficiencies of individual units can be adversely affected by the demands of the overall, continuous operation and the efficacy of the Fiberight process.

Why does the MRC, which represents 187 towns in Maine, contemplate abandoning the proven PERC technology for an, as of yet, unproven Fiberight technology that has been under "development for nearly a decade" yet has NO operating plants anywhere in the world? Has Fiberight truly completed the data collection/project planning stages necessary for the Hampden project when the process equipment keeps changing, the process flow diagrams are not provided in the permit applications, the sugar markets are not defined adequately, a saleable/"profitable" final product (i.e. ethanol made from trash or Trashanol) that was heavily promoted to sell the Fiberight process to Maine communities, is suddenly dropped and kept under wraps from its members to this day?

In addition, both the FBRI team members and the MRC members appear to have overlooked their "subject matter experts" view of the benefits that accrue with development of waste management projects (like Fiberight) on brownfield sites or on properties that are already developed and have significant infrastructure capabilities/advantages like the existing PERC facility in Orrington.

A summary of the experts' inquiries, comments and concerns are noted in Table 1 that follows this letter. A comprehensive11 page analysis follows the table with the various critiqued FBRI report sections, appendices and power point presentation references duly underlined.

Orrington's experts plan to review other aspects of the Hampden project from environmental, technical, and socio-economic bases after a thorough review of the various permit applications submitted by CES, Inc. If possible, please provide any and all comments or questions that you and your staff have pertaining to this initial submittal. If you should receive responses from the involved parties to the Hampden project, we would certainly appreciate the opportunity to comment. Please contact me at (207) 825-3340 or (207) 825-4519.

Sincerely,

Mr. Paul White - Town Manager
One Municipal Way
Orrington, ME 04474-3666

cc: Town of Orrington - Selectmen

## TABLE 1: Technical Review of Study by U Maine Engineering Group of the Fiberight Project for the Presented on February 4th, 2015 Municipal Review Committee (MRC)

| Doc.- Pg #-§#-Line # | Quotation - Point of Inquiry / Interest / Concern | Technical Analysis - Comments |
|---|---|---|
| **I. Major Process Flow Steps/Unit Operations keep changing, data unclear/not given to FBRI, or process was not tested** | | |
| SUM #7 - §1- #6-7 | "Fiberight is planning to ferment sugars to ethanol in Iowa, but is not planning this step in Maine" | Significant change not emphasized/highlighted at meetings – No "Trashanol" in ME/IA projects despite years of publicity |
| SUM #1 - §3- #3 | "no data on Fiberights' operating experience on combustion or gasification of residual post hydrolysis solids" | This presents an unknown risk in the engineering, design, procurement for MRC commercial plant in Maine |
| SUM #5 - §5- #2-3, 5-7 | "significant operating experience with a small commercial AD installation, using 8,000 gallon Voith R25 reactor" | "Fiberight now is working with Hydrothane" whose AD process Fiberight has not tested at pilot plant or demo level |
| SUM #8 - Flow Figure | Prior Samoset Resort Mtg-April 2014 shows wood waste as PEF (Process Engineered Biomass Fuel) but not apparent now! | What is to be done with wood wastes? Fiberight process won't digest wood to pulp/hydrolyze with enzymes to sugar |
| SUM #7 - §3- #9-10 | "Transportation of clean sugars to the end user will need to be evaluated for cost and possible contamination" | Expert APP D-#1 §3-#5 notes "the expense of drying sugars [to granular] to minimize shipping cost" is a major issue! |
| SUM #7 - §4- #2-3 | "Process description supplied by Fiberight does not adequate-ly specify on-site waste water treatment and disposal needs" . | Also noted in PPS #5–§1 #1-2 by FBRI Project Team. |
| SUM #7 - §4- #4-6 | "A full mass and energy balance should be obtained and reviewed because it is needed to fully understand....impacts" | MRC should be concerned with true capital costs of project, and whether tipping fees are justified for post 2018 period. |
| APP A #4,6-7- etc | 9-26-14 memo to Maine DEP has many Ethanol Fermentation references, but ethanol now been dropped from Maine project | Significant/not emphasized –No "Trashanol" in Maine project so why are capital cost high, tipping fees high/going higher? |
| APP B #2- §3- #2-3 | "Suspended solids are about 12%, but can be as high as 20%." | Personnel lab/pilot plant experience with high consistency hydrolysis shows 20% solids level is not technically viable! |
| APP B #2- §6- #1-2 | Fiberight "exploring moving the refiner" at VA pilot plant | Still experimenting to improve critical hydrolysis step! |
| APP B #2 - §5- #4 | "No data on the sugar purity was made available" | Major risk to Fiberight product sales and market development without detailed sugar purity data and specifications. |
| APP E - #1 - §1-#1-2 | "We do not have a detailed process flow diagram or a material balance that is necessary to estimate ....emissions" | Fiberight needs to define process flows/do economics study. |
| APP E -#2 -§6 –#1-3 | "Fiberight .... process is self-contained .... no by-products that must be managed" | "However, without detailed process flow diagrams.... it is not possible to confirm these claims" per subject matter experts! |
| **II. Some "Subject Matter Experts" concerns NOT highlighted, addressed, or are contradicted by FBRI** | | |
| APP D-#1-§6 –#1-3 | "... two thirds of total mass balance unaccounted for." | Can Fiberight answer/give material balance info to public? |
| APP D-#1-§7 –#1-3 | Poor "conversion of MSW....suggests a high level of inhibitors" | Further investigation required for how clean sugars must be! |
| APP E -#1-§5 - #1, 5-6 | "Brownfield sites offer potential advantages....should be considered a part of the facility siting process" | Not mentioned by FBRI in SUM Report or Power Point Slides. Brownfield or the existing PERC site or adjacent land may offer advantages over Greenfield (Hampden) |
| PPS #5 – 4-1 vs, SUM #9-§3 #11-13, APP #2 -$3-#1-4 | "Permitting process could take 6 months to one year" in PPS page 5 major bullet point 4 (PPS #5 –4-#1) | "Once FEL3 is completed, the permitting will take conservatively 12 months for a greenfield site" SUM #9-§3-12 |

KEY To Above Table - Column 1: Example: SUM #7 – §1- #6 is the Summary Report by the U Maine FBRI Group, page #7, paragraph 1, line #6
PPS = U Maine Power Point Slide Presentation
SUM = U Maine FBRI Summary Report - Technology Review of Fiberight Process for MRC
APP = Appendix A - E

## TABLE 1: Technical Review of Study by U Maine Engineering Group of the Fiberight Project for the Presented on February 4th, 2015 Municipal Review Committee (MRC)

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| **III. Final Products, By-products and Viable Market Concerns not adequately ID'ed as Risk Factor for Fiberight Project** | | |
| SUM-#1-§6–#1-3 | "odor issues limited to the front-end....are relatively odor free" | Only odor comment in SUM/PPS- no data! FBRI afterthought? Off-gassing likely in other process areas from spoilage |
| SUM-#7-§3–#7 | "Appendix D cautions having sugars as an end product" | Significant issue that Fiberight proposes to convert some to additional biogas production –how much/cost, how often, etc. |
| SUM-#7-§4–#6-8 | "With elimination of ethanol .... from Maine project, now there is no product with current established markets in Maine" .... Significant reliance on emerging markets for biomethane by AD" | Subject matter expert in APP D-#1 §3-#1-3 says "potential of selling cellulosic sugar on the sugar market...led OTFF and DOE to conclude that was not a viable market" |
| SUM-#7-§4–#9-10 | "sugars produced from hydrolysis....is unclear what portion will be used onsite versus sold" | Fiberight now plans to convert some to additional biogas production – how much/cost, how often, economical? |
| APP A-#8 - §2-#1 | "solids....,which is spent fiber with a high lignin content," | Unclear whether this is Process Engineered Biomass Fuel? |
| APP E-#2 - §8-#3-5 | "impurities build up in the system over time....this liquid waste would require some form of treatment" | Subject matter expert opinion versus view of Fiberight "that there are no by-products that must be managed"' |
| **IV. FBRI says no "scale-up issues anticipated" (but scale-up problems can occur with processes are tested only at lab/pilot plant scale)** | | |
| APP B - #1- §2 - #2 vs. APP C #1- §2 | "The plant can process 50 tpd of municipal solid waste (MSW)" vs "the facility accepts about 5 tons of MSW every two days" | Which plant size is it? 50 TPD is Demo scale plant size according to USDOE, while 2.5 TPD is small/Pilot Plant scale! |
| APP B - #2- §5 - #1- 2 | MSW "achieves about 40% hydrolysis conversion...." | Poor conversion impacts tank sizes/capital expense (CAP-EX) |
| NA | FBRI didn't visit commercial plant under construction in Iowa | Visit would likely have provided good scale-up insight to MRC |
| SUM-#1 - §2 - #4-5 | "third party has reported that sugars .... been used to produce ethanol on a laboratory scale" | Big problems typically occur scaling from lab to commercial. But if no "Trashanol" this mitigates problems for MRC project |
| APP B - #2- §10 - #1 | "The pilot plant does not have any fermentation ... capability" | No "Trashanol" planned in Maine so no problem now. |
| **V. Other Process, Engineering Points, Recommendations made by FBRI's Team but Ignored by MRC** | | |
| SUM-#1-§ 7–#3-6 | "Maine market analysis is recommended if biomethane, sugars and biomass are planned ... end products from the plant" | FBRI suggests independent market study based on analytical data and real sugar specs (free of impurities, contaminants) |
| SUM - #9-§ 2–#5-10 | "Fiberight ... with ... an independent engineer (Black & Veatch) | MRC should request this study and provide to DEP and public |
| SUM - #11-§2–#5-10 | "recommendation ... an owner rep..., be secured ... to complete or review the Front End Loading (FEL3) process | MRC does not have an "independent representative" to review the project, but is using own consultant G. Aronson. |
| APP C-#3-§2–#1-5, APP C Figure 12 & 13, APP B #2 § 10 #2 | "The chemical plant includes elaborate processes ... to create sugars, encourage fermentation and create ethanol and various other products.... selling ethanol to fuel blenders" | FBRI did not see fermentation tanks and reported that VA pilot plant was not able "to secure an environmental permit to produce ethanol" so what did MRC witness a year earlier? |

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**Town of Orrington – Submission - Part 1: Technical Review of Study by U Maine Engineering Group of the Fiberight Project for the Municipal Review Committee**

Over the past couple years, officials for the Town of Orrington have been quietly listening and studying the public pronouncements of the non-profit Municipal Review Committee, (the MRC) in its endeavor to "ensure affordable, long term, environmentally sound disposal of MSW" (Municipal Solid Waste) for its 187 members. These municipalities have their MSW hauled to the Penobscot Energy Recovery Company LP (PERC) waste-to-energy (WTE) plant in Orrington. USA Energy Group is the majority private owner of the facility at 52.7%; while a private limited liability partnership called PERC Holdings owns 24.3%, with the remaining 23% owned by the public Equity Charter Municipalities of the MRC (118 of the full 187 member committee).

Orrington is not a member of the MRC, has no voting authority at MRC meetings or input into the resolutions it has prepared nor has Orrington been consulted in what MRC post 2018 planning impacts on the town might be, how they could be mitigated, and/or what the town could offer the MRC or the PERC partnership that would assist MRCs' future solid waste disposal actions. Orrington has, of course, been able to attend the MRCs' public meetings and follow its activities. As host community for the very successful PERC operation, the Orrington town leadership has had the opportunity to see PERC's professionalism, their response to its citizen's need/interests and been witness to their civic mindedness.

Orrington has attempted to foster communications between the public owners (MRC) and private owners of PERC to ensure its continued operational success beyond March 31, 2018 when the existing lucrative electrical rate power agreements expire. Despite these considerable efforts, the parties seem to be heading in different directions that do NOT appear to be in the best interests of the various parties (equity owners in PERC; MRC communities; and non-equity towns/disposal authorities alike)!

The town is fortunate to have knowledgeable, professional property owners and citizens with expertise in waste reduction, recycling, material recovery, WTE, pulp and paper making and chemical engineering processes/unit operations and landfill, design, construction and operation. Such experience has afforded the town the opportunity to conduct an authoritative "peer review" of the technical aspects of the Fiberight technology, to offer complementary (or contrary) assessments of the FBRI review and the viability of the Fiberight process when such a technology is applied to a highly variable MSW stream.

The points of interests, inquiries, comments, and concerns highlighted below are limited to the University of Maine Technology Review report, the appendices, and the power point slides that were presented to the MRC at the quarterly meeting of the committee on February 4, 2015 by the Forest Bioproducts Research Institute (FBRI) team and subsequently made available on-line later in the week. The FBRI team consulted subject matter experts, and their input was referenced in the presentation, but they were not in attendance at the meeting. Their evaluations are in Appendix D – "Fiberight Technology Evaluation of Conversion of MSW Organics into Ethanol" by Darrell Waite, December 26, 2014; and Appendix E- "Site Infrastructure and Permitting Considerations" by James

Atwell, Dec. 29, 2014. The documents that Orrington has analyzed carefully and for which responses from the involved parties – MRC, Fiberight LLC or consultants (CES Engineering), Maine Department of Environmental Protection (DEP) are requested are as follows: FBRI Technology Review Fiberight Process for MRC – 11 page report (hereafter called **SUM**) with Appendices A-E (hereafter called **APP**) dated 1/30/2015, and U Maine Power Point Slide presentation (hereafter called **PPS**) dated 2/9/2015. Follow–up responses from Orrington's expert(s) will be made of the various permit applications that CES Engineering submitted on behalf of MRC and Fiberight to the Maine DEP on June 24, 2015 and which were deemed complete on July 15, 3015 by the department. (The U Maine FBRI Summary and appendices have been included in the 534 page Solid Waste Processing and Recycling Facility - Hampden, Maine at the end of the Attachment 13. The power point slide presentation was not included in the permit submittal).

The Town of Orrington's experts have taken excepts from the above documents and then made specific technical points, raised questions or has suggested that additional follow-up be made by the peer review team, the consulting engineers or the Maine DEP. The format for these queries in the following pages is to cite the source document referenced, the page number that the quotation/citation comes from and the specific paragraph and the line(s) the citation comes from. The Town's technical Inquiry/point for which a response is requested follows the quotation. As an example: **SUM #7 - §1- #6** is a citation from the Summary Report by U Maine FBRI Group, page #7, paragraph 1, line #6. The FBRI's report, appendices, and power point presentation are attached to this submittal. For convenience, each inquiry critiqued by Orrington's experts is noted in the left margin of the reports and the excerpted quote is underlined.

**Inquiry 1: The Fiberight process proposed for the MRC communities has changed repeatedly, the data that FBRI reviewed is unclear/incomplete/or was not provided to the FBRI or the Public (prior to February 4, 2015) and Various Processes have not been thoroughly tested to this day:**

a) **SUM #7 - §1- #6-7:** "Fiberight is planning to ferment sugars to ethanol in Iowa, but is not planning this step in Maine"
**Inquiry 1a:** During all of 2014, the MRC/Fiberight project was to produce "Trashanol" – that is ethanol made from trash. Fiberight planned to produce ethanol in Maine as late as the fall of 2014 (see APP A-#7 §3 #1+2 - Memo to Karen Knuuti, Maine DEP dated September 26, 2014) and this ethanol was to be made from trash by enzymatic hydrolysis that would be produced via fermentable sugars. By February 4, 2015, ethanol was no longer to be produced in Maine, and as of the week of April 12, 2015, ethanol was not going to be produced in Iowa. As recently as July 31, 2015, the Bangor Daily News (BDN) in an article titled "Group signs deal to send trash to Norridgewock", page D-4, Column 2, Trashanol is still referenced - "At the Hampden plant, Fiberights technology will change organic materials in trash into biofuels, called Trashanol..." This article has not been corrected. (See underlined sentence of attached BDN article).

What has precipitated these significant changes in the Fiberight project and has MRC communicated the reasons for the removing of one of the main

inducements for choosing the Fiberight process? Did FBRI's subject matter technical experts raise significant doubts about the viability of the Fiberight process to produce Trashanol, the lack of markets, or the technology's capability to even produce marketable sugars for sale? Why didn't the MRC tell the public and media present at the February presentation that Trashanol was no longer considered economically viable in Maine? (Why haven't they issued a press release about Iowa dropping Trashanol, too?) How realistic/valid is the Fiberight technology and MRCs' only alternative to PERC for post March 2018 waste management for its members that sign contracts with MRC?

b) **SUM #1 - §3- #3:** There was "no data on Fiberights operating experience on combustion or gasification of residual post hydrolysis solids" provided to FBRI. **Inquiry 1b:** The FBRI was not supplied analytical data characterizing the PHS that will have to be dried sufficiently for combustion. With no data to review, how can the FBRI assume there is no risk with the combustion of PHS produced from MSW? Has this PHS data been included in the June 2015 permit application submitted by CES Inc for DEP review?

c) **SUM #5 - §5- #2-3, 5-7**: Fiberight has "significant operating experience with a small commercial AD installation, using 8,000 gallon Voith R25 reactor... Fiberight now is working with Hydrothane who also supply Expanded Granular Bed (EGB) systems. Fiberight claims this system can tolerate suspended solids up to 2,500 ppm". Inquiry 1c: Has Fiberight tested this Hydrothane system at the Virginia pilot plant or demonstration plant level. It has not been tested in the Iowa plant since that plant has not even been built yet. Sound engineering principals, practices and good judgment would consider a new, untested/unverified piece of equipment to now be used by Fiberight as an unacceptably high risk for the critically important Anaerobic Digestion unit for the Hampden project. The FBRI should have alerted the MRC as to this risk.

d) **SUM #8** - Flow Figure: At presentations of the Fiberight process at the Samoset Resort meeting in April 2014, and by the FBRI team in February 2015, the flow diagrams show the wood waste as Process Engineered Biomass Fuel (PEBF), or as "other" but it has changed again.
**Inquiry 1d**: What is to be done with the wood wastes? Fiberights' enzymatic hydrolysis process won't digest raw wood to sugars, only the surface fibers. Wood must be cooked under high temperature & pressure/chemicals to remove lignin (considered to be a major inhibitor of the enzymatic processes) and to generate individualized cellulosic fibers before enzymes can convert them to glucose and xylose sugars. (Note: The June 26, 2015 Permit App – Solid Waste Processing & Recycling Facility – Project Overview - Flow Process flow Diagram now shows Engineered Fuel Briquettes). Is this a brand new unit operation that the FBRI team has not seen? Are Engineered Fuel Briquettes (EFB) the same as PEBF and has this been produced at the Virginia pilot plant facility and tested? What is the heat content of the EFB and are there any constituents that would preclude its use with outdoor grills? Do the June permit applications indicate what volume is to be produced and what is the market potential for EFB? In the end, EFB is still burned in some manner the same as at the PERC facility so where is the environmental benefit for the Fiberight process for this material in the MSW?

e) **SUM #7 - §3- #9-10:** "Transportation of clean sugars to the end user will need to be evaluated for cost and possible contamination":
**Inquiry 1e:** Has Fiberight completed the demonstration, at something beyond lab scale, of the means and methods to produce clean, marketable sugar and to store it effectively on-site prior to shipment? Has Maine DEP seen in the permit application submittals produced by CES a valid study proving that Fiberight knows how to produce, store and ship clean, industrial sugars? Who in Maine will take the sugar and in what form will the sugar be? Industrial sugars in a liquid form made from clean, high cellulose pulp fiber via enzymatic hydrolysis have organic acids at very low concentrations that must be removed before successful marketing to industrial clients. FBRI's outside expert, Mr. Waite, **APP D-#1 - §3-#5** notes that Old Town Fuel and Fiber, (OTFF) "along with the US Department of Energy (DOE), investigated the potential of selling cellulosic sugar on the sugar market... led OTFF and DOE to conclude that this was not a viable option. These issues included ... the expensive and time consuming requirement to create this market, the impracticality of competing with the global sugar markets, and the expense of drying the sugar to minimize shipping costs." The various process steps/unit operations drive the economics of the products to be manufactured. How many tons of "clean" sugars are to be made and what are the production costs and projected selling prices per ton of that sugar? If Fiberight has not proven in its economic proforma analyses that marketable sugars are not needed, and has not proven the quality of its sugars at pilot scale or full demo scale, there is a high risk to MRC and involved communities that Fiberight will not be economically viable and will not, as the MRC desires "ensure affordable, long term, environmentally sound disposal of MSW" for its members in the post-2018 era.

f) **APP B #2 - §3- #2-3:** "Suspended solids are about 12%, but can be as high as 20%" for the pulp being treated with enzymes for hydrolysis conversion to sugar.
**Inquiry 1f:** Enzymatic hydrolysis of cellulosic fibers in the industrial sector has shown that high consistency conversion at 20% solids level is not technically or economically viable. Poor mixing at high consistency is the cause of this poor performance, as FBRI alludes to in the same section.

g) **APP B #2 - §6- #1-2:** "Fiberight is interested in exploring moving the refiner to process the isolated hydrolysate solid leaving the hydrolysis reactor" at the Virginia pilot plant.
**Inquiry 1g:** Less than a year ago, a FBRI team member report of December 10, 2014 noted that Fiberight was still experimenting with the feasibility of moving equipment to improve the critical cellulose to sugar hydrolysis conversion step. If the process equipment is not yet fixed and if the process has not been tested at even the pilot scale level, how can FBRI be comfortable with the viability of the technology? How can Fiberight be in a position to provide material and energy balances and thus guarantee that the economic projections of capital and that operating costs, fees, returns on investments, are valid for the Hampden project?

h) **APP B #2 - §5- #4:** "No data on the sugar purity was made available".
**Inquiry 1h:** FBRI refers to "clean" sugars suitable for hydrolysis but assumes that it is clean enough for the sugars market? If the FBRI team has not been provided with sugar purity information, any FBRI considerations of viability of industrial sugars production is moot. Also, their conclusions as to the scalability and soundness of the Fiberight process are speculative rather than based on standard engineering

principals. The production of industrial sugars, as OTFF was doing from clean, brownstock cellulose fiber is the best-case scenario for producing a quality sugar that is marketable, in contrast to the cellulose found in municipal solid waste with all the inherent contaminants that are present.

i) **APP E #2 - §6- #1-3:** "Information provided by Fiberight seems to indicate that the process is self-contained and that there are no by-products that must be managed" **Inquiry 1i:** Again, FBRI subject matter expert James Atwell reported that "without detailed process flow diagrams and a mass balance, it is not possible to confirm these claims" by Fiberight. (Note: In laymen's terms, a mass or material balance is a basic process flow diagram that shows everything that goes into process step(s) and everything that comes out. The total amount of solids, liquids, and gases (emissions) going **into** the plant must equal/balance with the total material that comes **out** of the operation/facility. An energy balance is the same balance of in's and out's, but shows heat, gas, steam, electricity, etc.) Now that all the permits have been submitted to the Maine DEP and the process design "finalized" for the Hampden facility, Fiberight should be in position to provide a simplified, yet accurate material and energy balance that will afford the public and all outside experts an opportunity to conduct an objective analysis of the project.

These balances are critical to assess that economics of the Fiberight process, and will distinguish between whether the process works, how well it works, is it economically feasible, and the return on the capital investment in a "best case and worst case" scenarios. No project should proceed without a good material and energy balance in place (and available to the public). There are too many unknowns with the Fiberight technology for the MRC to commit its membership to.

**Inquiry 2: The concerns of the "Subject Matter Experts" were not adequately highlighted, addressed or are contradicted by the FBRI team members.**

a) **APP D #1 - §6 - #1-3:** "One important note on the mass balance is that when the by-products (plastics, metals, glass and rigid plastics) are added together with the amount of sugar, there is still approximately two thirds of the total mass unaccounted for".
**Inquiry 2a:** Apparently, Fiberight provided one of the "subject matter experts", Mr. Waite with material balance info, but not to Mr. Atwell. Mr. Waite was not able to close the material balance, and there was no indication that neither FBRI nor Fiberight addressed the issue with the subject matter experts. As requested in **Inquiry 1i)** above, will Fiberight, the MRC and/or CES Inc. release to the public a complete process flow diagram and the corresponding material and energy balances for the Hampden project? This will allow other experts to review the project, assess the thoroughness of the design and the economic viability of Fiberights' joint project with the MRC.

b) **APP D #1 - §7- #1-3:** "Fiberight data on conversion of MSW derived sugar conversion to ethanol was much lower than both woody biomass derived sugars and corn dextrose. This suggests that a high level of inhibitors may be present in the MSW sugar that may diminish ethanol conversion efficiency."
**Inquiry 2b:** Although the Fiberight project in Hampden will not produce Trashanol (alcohol from trash), as is also the case for the project in Iowa, the need for clean sugar with no contaminants, (i.e. inhibitors) is critical if Fiberight and the MRC have any hopes of selling the produced sugars to the industrial market sector or for internal use by Fiberight for subsequent conversion to methane gas (biogas) via Anaerobic Digestion. (**See also Inquiry 1e**). The MRC, the municipalities contemplating abandoning the proven PERC technology for an as of yet unproven technology that has been under "development for nearly a decade" yet has NO operating plant anywhere in the world needs to be critically reviewed by the Maine DEP before the joint MRC/Fiberight permits are approved! Common sense would dictate to the MRC that to continue to pursue the Fiberight technology without confirmed tests of the quality of sugar at something above a test tube or lab scale level, or proof that the recipient of the Fiberight sugar can produce a quality finished product, and a comprehensive sugar marketing plan is not based on sound engineering/economic principals and is a high risk proposition for all involved parties. If the Fiberight venture fails, what then? The MRC communities are left without a viable option, as the PERC facility may have already been forced to close due to a lack of MSW to process.

c) **APP E #1 - §5- #1, 5-6**: "Brownfield sites offer potential advantages over a Greenfield site, based on existing permits and available infrastructure for power, and wastewater treatment... However, potential brownfield sites should be considered as part of the facility siting process"
**Inquiry 2c:** The FBRI team and the MRC appear to have overlooked their subject matter expert, Mr. Atwell on the benefits of "brownfield sites" in terms of capital and operating costs, socio-economic, environmental permitting, and time saving factors. MRC and Fiberight should compel the U Maine Peer Review team and/or CES, Inc. engineering firm to consider the existing PERC facility or the surrounding industrial park in Orrington for a new facility. Such a siting and permitting

approach would also afford the new MRC/Fiberight facility the opportunity to utilize PERC's existing roads, truck weighing station, front-end MSW size reduction/handling equipment, the boiler's excess low pressure steam from the power generation boilers, and the industrial parks' rail and roadway infrastructure. The Maine DEP needs to consider both the Hampden site and the Orrington site as part of the larger waste management strategy. If both fail, then there will be two "brownfield" sites that have to be brought back to state environmental standards.

The Maine DEP needs to require the MRC and Fiberight to consider alternative sites, specifically the PERC facility and the Orrington Industrial Park as an alternative to the "greenfield" project in Hampden in the permit application submitted in June by CES. The brand new environmental impacts of the Hampden project on the nearby residents, the construction of new roads thru wetlands, requirements for stormwater runoff/management, etc. should dictate a comprehensive review of the PERC facility and its surrounding properties with its many environmental benefits.

d) **PPS #5 – 4-1 vs. SUM #9 - §3 - #11-13 and APP D- #2 - §3- #1-4:** "Permitting process could take 6 months to one year" in the PPS on page 5 (major bullet point 4) while FBRI **SUM #9-§3** says "Once FEL3 is completed, the permitting will take conservatively 12 months for a Greenfield site", and subject expert Mr. Waite gave his opinion that the Fiberight "technology is 3-5 years from **beginning** commercial deployment". (See APP D- #2 - §3- #1)
**Inquiry 2d:** Why did the U Maine FBRI team shorten the expected permitting period for the Fiberight project in Hampden in the power point slide when their expert rightly states that the technology is 3-5 years away. Mr. Waite goes on to say, "A FEL 1 engineering study should be completed to determine the extent of the capital outlay and determine if the process is economically feasible" (See APP D- #2 - §3- #2-4). So, after FBRI's expert opined that the Fiberight process had not even satisfied Front-End Loading (FEL) Project Planning Stage 1, FBRI also states that FEL 3 "will need to be completed to have all basic data and information to file for permits". This was the status of the project in February 2015 and should be very disconcerting to the MRC and to the permitting authority (Maine DEP). Has Fiberight truly completed the data collection/project planning stages necessary for the Hampden project when the equipment keeps changing (See Inquiry 1g), the sugar markets are not defined adequately (See Inquiry 1f), the mass balances are not closing (See Inquiry 2a).

From the time that the FBRI team presented its peer review study for MRC/Fiberight on February 4 to the submittal of the permit application by CES on June 24th, 2015, 6 months have already passed, and all the data is clearly not included in the permit application that has been submitted to the Maine DEP and has guaranteed a processing time of 365 days (except if the Commissioner determines a public hearing is required).

The Maine DEP (and the MRC) cannot go forward in what may be an irreversible manner and approve the permit application without better and complete data from Fiberight.

**Inquiry 3: (By) Products and Market Concerns are not Adequately Identified by the FBRI as a Significant Risk Factor to the Viability of Fiberight Project.**

a) **SUM - #1- §6 - #1-3:** "Fiberight ... showed that odor issues are limited to the front-end of trash handling and sorting, with areas beyond the pulp washer ... are relatively odor free".
**Inquiry 3a:** The statement of "relatively odor free" by FBRI is not deemed to be accurate for enzymatic hydrolysis of MSW. Hydrolysis of cellulosic fibers from clean brownstock pulps when stored in tanks just a day too long must be managed to prevent odor generation. Given the variable input quality of MSW, bad batches and spoilage may occur. Storage tanks of PHS and sugar containing hydrolysate will also be subject to spoilage unless the solutions are repeatedly heated to suppress bacterial and fungal growth. The storage tank areas are also subject to off-gassing, and solids dead zones that can become septic if not mixed completely. Maine DEP needs to ensure that **all** process buildings are under negative pressure to avoid off-site odor issues. What was the cleaning schedule of the Fiberight process tanks in Lawrenceville Virginia? The DEP needs to understand the variable operating nature of the pilot plants and its more frequent cleaning experience does not replicate the demands for a comprehensive plan for cleaning the tank system at the Hampden facility to avoid odor generation.

b) **SUM - #7- §4 - #9-10:** "There appears to be a significant reliance on emerging Maine markets for biomethane produced from AD, sugars produced from hydrolysis, and residuals unhydrolyzed biomass." It is unclear what portion will be used onsite versus sold".
**Inquiry 3b:** As noted in Inquiry 1e, Fiberight did not provide FBRI with information on the means and methods to produce clean sugars, the markets in Maine or the region that are proven capable of using the MSW produced sugars, or the quantity and quality of the PHS. FBRI should have flagged this as posing a high risk to the viability of the Fiberight project in Hampden. If the permits do not identify proven/real/viable outlets for the sugars, then one could assume that all produced sugar will be converted in the AD to biomethane. The capacity and throughput of the AD unit(s) must be sized for the maximum sugar production rate. The Maine DEP needs to scrutinize the material balances for the entire project and have the applicants provide some basic economic projections with best case/worse case scenarios for which products (digester gas, sugar, PHS) have the greater market potential based on value and cost to produce.

c) **APP E - #2- §8 - #3-5:** "Even though Fiberight indicates that wastewater emissions would be low, or non-existent, our experience is that impurities build up in the system over time and these impurities must be purged from the system. This liquid waste would require some form of treatment, and would have to be considered in the permitting process."
**Inquiry 3c:** Fiberight indicated, "that there are no by-products that must be managed" but this clearly is not realistic/believable. The subject matter expert, Mr. Atwell is correct about the cycling up of impurities unless they are purged routinely. This applies to cycling up of contaminants in the sugar solutions as well. Maine DEP needs to scrutinize the emission data, (water, wastewater, air, odor, etc) in the Permit Application submittals in light of the claims made by Fiberight in documents submitted for peer review!

**Inquiry 4: FBRI has stated in their summary report that "Processing equipment used for MSW pulping, is sufficiently similar to what has been deployed in the pulp and paper industry so that scale up is not an issue"** (See SUM - #9- §1 - #3-5) **or FBRI stated "no scale-up issues are anticipated"** (SUM - #6- §6 - #2-3) **for the pretreatment and hydrolysis steps in Fiberight process.**

a) **Inquiry 4a:** The Maine DEP has, of course much experience in reviewing pulp and paper industry related projects/applications. Orrington peer reviewers are also knowledgeable about pulp and paper sector issues. The paper industry is replete with many projects that have **failed** to come to fruition when vendors have attempted to make recycled pulp fiber from MSW and even source separated waste paper. The Fiberight process is in essence trying to produce a clean enough fiber (like recycled pulp) via cooking and washing to then yield cellulosic fiber that can be effectively hydrolyzed to clean sugars. The cooking of the MSW would be done in a proposed Vicker Seerdrum continuous pulper (according to FBRI or are these steps to be done with Andritz equipment, which FBRI also referenced). FBRI notes that the two stage pulp washing unit made by Milnor is a piece of equipment that is sold for the purpose of washing laundry on cruise ships (See APP B- #1- §6- #1-2).

   Orrington peer reviewers consider a project that scales up cruise ship clothes washer equipment to be too far removed from the real world equipment used in the pulp and paper industry. Thus, the use of the Milnor equipment represents a significant risk to Fiberight project success. The Orrington expert reviewers also are concerned about scale up issues when projects are attempting to go from lab scale to commercial level, pilot plant to commercial level, and even demo plant scale to commercial scale. (See queries/comments below).

   Finally, just because the Fiberight process is using equipment that "is sufficiently similar to what has been deployed in the pulp and paper industry" for some of the individual process steps, it is very unlikely that there will be "no scale up issues" when all these process steps are joined into the **overall** Fiberight process.

b) **APP B - #1- §2 - #2: vs. APP C - #1- §2:** The **APPENDIX B** quote from FBRI's Mr. Bilodeau reported from his Nov 11, 2014 visit to the Virginia facility that the "plant can process 50 tpd of municipal solids waste (MSW)" while in APP C (a report from a December 19, 2013 visit by MRC) noted that "At present, the facility accepts about 5 tons of MSW every two days" (or 2.5 tons per day).
   **Inquiry 4b:** The owner of Fiberight touts 5000 hours of operation of the Virginia Fiberight plant. How many hours has the plant operated at the 2.5 tpd level, which is a small pilot plant versus how many hours at a demonstration plant level? The bulk of the hours are likely from the small demo level, which was reportedly brought on line in the summer of 2010. (5 years or 1825 days ago) Regardless, 5000 hours is only 208 days of continuous operation (slightly over 11% running time), with most of that operation at the pilot plant level. The scale up factor from the 2.5 tpd to the commercial scale level of 600 tpd of the Hampden plant is recognized by US government agencies, like the Department of Energy as a huge risk, and actually too high to truly be comfortable that the plant will start-up and operate as planned. Fiberight and the MRC have been holding out hope that the

Iowa plant (designed to operate at a 450 tpd rate) would be running by now, but it is not expected to come on line until 2016. Given the limited operation of Fiberight, Orrington peer reviewers anticipate that scale up issues will occur.

c) **APP B - #2- §5- #1-2:** "Fiberight achieves about 40% hydrolysis conversion, on a solids basis...The hydrolysis reaction takes between 60-72 hours to complete."
**Inquiry 4c:** This low conversion rate and long conversion time (3 days) using MSW has a large impact on tank volumes, pump sizes, and thus capital expenses. The Maine DEP needs to have the applicants verify that the design specifications of the process equipment/systems are adequate to handle poor hydrolysis conversions, extended batch operations, and enzyme dosage gaps. At the design capacity, is there sufficient installed boiler capacity to provide drying of PHS, dry sugar for commercial sale, building heating, lighting, etc.

d) **SUM - #1- §2 - #4-5:** "A third party has reported that sugars from the Fiberight process have been used to produce ethanol on a laboratory basis".
**Inquiry 4d:** FBRI has stated in its summary "that scale up risk is not an issue" or "no scale-up issues are anticipated". Given that Fiberight has dropped the concept of producing "Trashanol", i.e. ethanol from trash in both Maine and Iowa, the point may be moot for FBRI. But in the Orrington experts' opinion, unless FBRI had actually seen Fiberight produce bulk quantities of ethanol at their Lawrenceville plant and had not simply been told that the Fiberight process has had lab quantities made for them, scale up risks should have been flagged as an issue.

e) **APP B - #2- §10- #1:** The Lawrenceville, Virginia pilot plant "does not have any fermentation or ethanol processing capability" based on FBRI team member Mike Bilodeau's visit on November 11, 2014.
**Inquiry 4e:** Again, this may be a moot point given the dropping of Trashanol in Maine and Iowa. But the FBRI's observations should have been an alert to the MRC that Fiberights statements about producing ethanol was limited to a brief run at Fiberights' used ethanol plant in 2010 in Blairstown, Iowa and not at the pilot plant in Virginia. See also Inquiry 5d below.

**Inquiry 5: Other Points of Concern, Issues, Recommendations made by FBRI's Team, but which have been ignored by MRC for the Fiberight Project in Hampden.**

a) **SUM –#1- §7- #3-6:** "The selection of final products produced from this process will have a large impact on the economics of the project. *A Maine specific market analysis is recommended if biomethane, sugars, and biomass are planned to be significant end products from the plant.*" (Emphasis added.)
**Inquiry 5a**: As the FBRI team recommends, will the MRC have an **independent** market study conducted and submitted to the Maine DEP during their Permit Application review process. The study needs to be based upon proven analytical data that the Fiberight process has actually produced gas pipeline quality methane, that the sugar quality is free of impurities/contaminants and will meet industrial sugar quality specifications, and that the biosolids can be dried and turned into a viable fuel, soil amendment product, etc.

b) **SUM -#9- §2- #5-10:** "Fiberight is also working with an independent engineer (Black & Veatch) in connection with an USDA loan guarantee application for the Iowa plant. The Independent Engineers Report on Fiberights' Iowa project will provide significant information that would be useful for evaluating a business case for the proposed project for MRC in Maine. Such a report may contain details on the material and energy balances…"
**Inquiry 5b:** Will the Fiberight/MRC provide the Black & Veatch report to the Maine DEP and allow them to post a non-proprietary 'public' copy online?

c) **SUM -#11- §2- #1-6:** "An immediate recommendation is that an owner's representative or lender's representative, similar to what DOE and USDA require for their programs, be secured for the Maine project. This representative should have the capability to complete or review the Front End Loading (FEL3) process for the Maine project… This representative should focus on a independent Engineering Review and Risk Management for the MRC."
**Inquiry 5c:** It is strongly recommended that the MRC hire someone like Sevee and Maher Engineer, Inc. to conduct or complete a FEL3 review of the project and provide a public (non-proprietary) document on the Hampden project.

d) **APP C - #3- §2- #1-5, APP C - #4 - Figure 12 and 13, and APP B - #2- §10- #2:** "The chemical plant includes elaborate processes … to create sugars, encourage fermentation and create ethanol and various other products (Figures 12 and 13). Fiberight is selling the ethanol to fuel blenders for $1.80 per gallon, which translates to $32.40 per ton of incoming MSW at a production rate of 18 gallons of ethanol per ton of MSW."
**Inquiry 5d:** How did the MRCs' representatives Greg Lounder and George Aronson see fermentation and ethanol production during their December 19, 2013 visit when the FBRI's representative Bilodeau on November 11, 2014 noted in Inquiry 4e above that the plant "does not have any fermentation or ethanol processing capability"? The MRC trip report Figure #12 in Appendix C depicts "fermentation tanks" when it is actually the sugar hydrolysis tank! Figure 13 is titled "Ethanol Production", but the Virginia pilot plant was not able "to secure an environmental permit to produce ethanol for the site" (See APP B - #2- §10- #2) How was Fiberight at the Virginia pilot plant selling ethanol (Trashanol) to fuel blenders for $1.80 per gallon? Did the MRC representatives get misled during their Virginia trip in 2013 on Fiberights' capabilities to make Trashanol?

THE UNIVERSITY OF MAINE
Forest Bioproducts Research Institute

# Technology Review Fiberight Process for MRC

Dr. Hemant Pendse, FBRI Director
Michael Bilodeau, PDC Director
Amy Luce, TRC Manager, Process Group Leader
Darrell Waite, Formerly Process Manager, Biorefinery and Director of Technology, Old Town Fuel and Fiber, Old Town, ME
James S. Atwell, P. E., Sevee & Maher Engineers, Inc.

1/30/2015

# I. Summary:

FBRI was asked to review Fiberight's technology to convert Municipal Solid Waste (MSW) to biofuels and other products. The scope of the review was limited to the biological and chemical conversion of the organic fraction of MSW to liquid fuels and other products. In order to accomplish this task a detailed study of the technology was done which included a site visit to Fiberight's demonstration facility in Lawrenceville, VA. Subject matter experts were consulted to offer comment on process readiness in comparison with similar known biofuel projects and applicable environmental considerations.

The evaluation team concluded that Fiberight's processing technology is sound and capable of converting the insoluble portion of MSW organics to a simple sugar solution. Presently at their pilot plant, Fiberight has successfully used sugar solutions from both the insoluble and soluble portion of MSW to produce biogas through anaerobic digestion (AD). A third party has reported that sugars from the Fiberight process have been used to produce ethanol on a laboratory scale.

Inquiry 4d

1. The equipment and processing steps that constitute the proposed technology are similar to existing equipment and processing steps found today in the pulp and paper industry and in related fields.
2. There are no concerns regarding the scaling up of the technology from the scale demonstrated at the Fiberight facility in Lawrenceville, Virginia, to the scale proposed for the MRC-sponsored facility, particularly for production of biogas and clean sugars. There was no data on Fiberight's operating experience on combustion or gasification of residual post hydrolysis solids at Lawrenceville, VA.

Inquiry 1b

3. Fiberight has demonstrated that its technology can convert the organic fractions of MSW into clean, fermentation-ready sugars without significant inhibitors.

Inquiry 3a

4. The experience at the Fiberight facility in Lawrenceville, Virginia, showed that odor issues are limited to the front-end of trash handling and sorting, with areas beyond the pulp washer are similar to the a paper mill and are relatively odor free. Issues related to air emissions would arise based on combustion or gasification of residual biomass and post hydrolysis solids. Although Lawrenceville VA experience is not directly applicable to Maine's winter operations, Fiberight's experience in Iowa should prepare them in addressing winter operation issues.

The economics of the Fiberight process were outside of the scope of the project and are not reviewed in this report. The claimed hydrolysis efficiency is somewhat lower than that reported for other biofuel feedstock processing technologies, potentially due to the MSW origin. The selection of final products produced from this process will have a large impact on the economics of the project. A Maine specific market analysis is recommended if biomethane, sugars, and biomass are planned to be significant end products from the plant.

Inquiry 5a

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## II. Scope:

This review is based on analysis of the elements of the Fiberight technology that involve biological and chemical conversion of the organic fraction of MSW to liquid fuels and other products. The primary aim of this study is to provide the Municipal Review Committee (MRC) with insights regarding the feasibility and viability of the reviewed aspects of the Fiberight technology. Additional limited analysis was conducted to obtain relevant perspectives regarding the Fiberight technology on environmental permitting, host site selection, and technology scale-up issues.

Specific concerns raised by MRC regarding the implementation of new technology in Maine include the following:

1. The extent to which the equipment and processing steps that constitute the proposed technology are similar to, or represent a departure from, existing equipment and processing steps found today in the pulp and paper industry and in related fields.
2. Concerns regarding the scaling up of the technology from the scale demonstrated at the Fiberight facility in Lawrenceville, Virginia, to the scale proposed for the MRC-sponsored facility, with special attention to the continued viability and the potential for changes in performance of the technology at the larger scale.
3. Whether Fiberight has demonstrated that its technology can convert the organic fractions of MSW into ethanol or other liquid fuels or chemical products that meet commercial specifications.
4. Whether the experience at the Fiberight facility in Lawrenceville, Virginia, provides the basis for concerns that an MRC-sponsored Fiberight facility might result in issues related to air emissions, odor emissions, solid or liquid wastes requiring special treatment, or other potential emissions or nuisances.

## III. Process Review:

The Fiberight process description with a process flow diagram is reproduced as Appendix A. This was extracted from the information packet submitted to Maine DEP by MRC on September 26, 2014. Based on a site visit by Michael Bilodeau, this process flow has changed slightly, and the updated process flow is described in his site visit report in Appendix B.

### A. Front-end Separation System

Review of the US EPA Decision document[1] dated June 2012 indicated that approval of the "Fiberight Separation Plan" means that separated-MSW feedstock produced according to the submitted separation plan for Blairstown, Iowa, with its associated addendum, qualifies as renewable biomass. Thus, Fiberight may use such separated-MSW to produce certain renewable fuels that generate RIN credits. The Fiberight Separation Plan was deemed to be equivalent to a fully functional municipal recycling facility (MRF) as a front-end to their waste-to-energy plant. Fiberight had assumed no prior separation of the waste stream. This is important for the communities not served by curbside recycling. The Fiberight Separation Plan provided for separation of recyclable aluminum, ferrous and other metals, plastic containers, film plastic, glass, aggregate, and organics to the extent reasonably practicable. Fiberight proposes to produce 'recovered recyclables' as products for end markets. The significance of a fully functional MRF as a front-end can be evaluated by the MRC to the extent curbside sorting and recycling practices are applicable to the anticipated waste stream coming to the proposed facility.

Once the initial recyclables have been recovered, the MSW is processed in a pulper at 160°F to 180°F with the addition of water and heat. This creates conditions to allow the organic, primarily food and paper, to break down forming a fine particulate biomass. Once the biomass is produced, it has a much smaller particle size than the remaining materials allowing a high level of separation in standard MRF equipment. The biomass is cleaned in a two-stage washing tunnel where first the soluble organics are removed for the feed to the anaerobic digester, and then the high-cellulose biomass pulp is separated from any small inorganic contamination.

### B. Conversion of MSW Organics

For the present review, we focused on evaluating the proposed technologies for conversion of MSW organics, including: (1) soluble organics derived from organics in the mixed MSW, and (2) insoluble organics derived from cellulosic waste, compostable or soiled fiber, and low-lignin yard waste. Fiberight proposes to convert wash water rich in dissolved organics into biogas, and convert washed and pre-treated cellulosic solids into a filtered and concentrated sugar solution.

The biogas can be upgraded on-site to pipeline quality methane-rich gas for injection into a natural gas pipeline or further compressed for use in CNG (compressed natural gas) vehicles as one or more co-products. The sugar solution will be concentrated and sold to a third party as cellulosic sugar.

[1] http://www.epa.gov/otaq/fuels/renewablefuels/documents/fiberight-decision.pdf

### 1. Anaerobic Digestion

Fiberight proposes to use a "liquid-only" high capacity anaerobic digestion (AD) system to process wash water rich in dissolved organics derived from mixed MSW. This type of reactor system is claimed to produce clean water that can be reused in the washing process and not generate significant quantities of digestate. It should be noted that Fiberight proposes to process only 'soluble' organics in their AD system.

Commonly AD systems have been used to process both dissolved solids as well as suspended solids. When total solids level is less than 15 wt % the digestion is called 'wet', and when total solids level is 25-30 wt % it is called 'dry'. Often, dewatered solid organics are subjected to composting.

The most suitable feedstock for current commercial Anaerobic Digesters is often described as:

- Animal waste and biowaste from wastewater treatment plants
- Food and kitchen wastes from restaurants, canteens, food markets, and municipal source- separated food wastes.
- Organic waste from food processing industry, slaughter houses, etc.

Source Separated Organics are comprised of food waste, paper napkins, and used kitchen paper, as well as green waste. The "all other" fraction is the waste that remains after the recyclable and compostable materials are separated at the source by the citizens at curbside. Most AD plants process "source separated organics (SSO)" but attempts to process organics separated from mixed MSW have proven to be quite challenging. These reported operational problems often come from suspended solids in the feed.

Inquiry 1c

For Fiberight's 'soluble organics only' feed case, AD operations are expected to be more efficient and less problematic. Our site visit indicated that Fiberight has accumulated significant operating experience on biogas production with a small commercial AD installation, using a 8,000 gallon Voith[2] R2S reactor with a maximum capacity of 1,320 lb COD/day. Based on the initial work with Voith, they found there was a limitation of 500 ppm in the feed to the AD. Fiberight now is working with Hydrothane who also supply Expanded Granular Bed (EGB) systems. Fiberight claims this system can tolerate suspended solids up to 2,500 ppm and gives more flexibility. This type of AD is in Fiberight's plan for their site in Iowa. The scale up of the AD is not expected to be an issue. Fiberight's proposed plans for Maine include possible biogas upgrading for input to a natural gas pipeline or production of CNG.

### 2. Enzymatic Hydrolysis to produce clean sugars

Fiberight proposes to use washed MSW-derived pulp press cake (over 40 wt. % solids) for producing clean fermentable simple sugars. The key step is the thermo-mechanical pretreatment involving pH adjustment and cooking at 260°F for 30 min residence time using steam injection in a pressurized vessel,

[2] http://www.vp-environmental.com/en/Industrial_Environmental/Wastewater/Anaerobic_Biological_Treatment/R2S-Anaerobic_Reactor.html

followed by low consistency (3 to 4 wt.%) refining and dewatering that produces clean and sterile MSW-derived pulp press cake. This MSW-derived pulp is similar to what Old Town Pulp mill was using out of their brownstock washers as far as suitability for hydrolysis is concerned. Actual hydrolysis efficiencies, enzyme loading requirements, and cleanliness of resulting sugars are expected to be quite different for MSW-derived pulp versus brownstock (unbleached chemical) pulp.

Fiberight has an active partnership with a major enzyme supplier (Novozymes) for hydrolysis of pretreated MSW-derived pulp. Unhydrolyzed solids can then be separated from sugar solution using a filter press. Filtered sugar solution can be concentrated using evaporators and/or membrane filtration with evaporator condensate being reused onsite.

This portion of the processing is similar to the brownstock pulp hydrolysis scheme planned for the Old Town mill. The brownstock pulp contains liberated virgin wood fibers from woodchips with lignin and some hemicellulose removed in the black liquor through the chemical pulping process. The black liquor solids are burned in a recovery boiler at a pulp mill providing steam and power. After cooking, the pulp is washed to remove spent chemicals and dissolved lignin prior to hydrolysis. Hydrolysis efficiency for the brownstock pulp is found to be 90% to 95% on the basis of complex carbohydrate content in the brownstock. Resulting simple sugars then need to be cleaned to remove various potential inhibitors.

Fiberight has partnered with Andritz, a major supplier to the pulp and paper industry, to supply the cooking systems for their full scale plants.

The MSW derived insoluble organics are subjected to the thermo-mechanical pretreatment outlined above to prepare the pulp for hydrolysis. Hydrolysis efficiency for the carbohydrate in the MSW-derived pretreated pulp is in the 40 to 50 w/w% range as reported in Michael Bilodeau's site visit report in Appendix B. For example, with hydrolysis feed containing 80% carbohydrates one would get 60% mass out as unhydrolyzed solids at 50% hydrolysis efficiency. The efficiency is low in comparison with virgin cellulosic undried pulp, due mostly to a phenomenon known as hornification. When cellulosic pulp fibers are dried in papermaking, the internal volume of the fiber shrinks. When the fibers are rewetted, they do not swell to the original volume. This lack of swelling to the original state is known as hornification. Due to this occurrence, the enzymes don't have easy access to all of the fiber surfaces, like they do in undried virgin pulp. Fiberight uses some refining to open up the fibers for better enzyme efficiency and is working on a plan to improve this process. Improvements in enzyme technology could aid in the conversion efficiency in the future. The unhydrolyzed solids can be used as biomass fuel if dewatered to low enough moisture content, and burned onsite for steam and power needs of the facility. The resulting sugars need to be evaluated for fermentation yield using selected microbes. Fiberight has reportedly benchmarked such sugars for fermentability to ethanol with the help from Novozymes.

Inquiry 4a

Fiberight has accumulated operating experience on a 1500 gallon hydrolyzer and associated pre-treatment set up in their pilot facility, using current technology. No scale-up issues are anticipated for these steps.

### 3. Utilization options for MSW derived sugars

Fiberight and Novozymes have carried out a number of bench scale tests converting sugars produced from Fiberight's biomass pulp. The results demonstrate that the conversion of the C6 sugars to ethanol is within industry standards. Technology for fermenting sugar into ethanol, irrespective of the source of sugar, can be supplied by a yeast supplier as long as sugars meet the minimum quality specifications and are available at the required feed rate in a reliable fashion to support the installed processing capacity. Fiberight is planning to ferment sugars to ethanol in the plant in Iowa, but is not planning this step in Maine.

Inquiry 1a.

As part of Fiberight's development process, modifications were made to the plant in Blairstown to allow the plant to run paper mill sludge. Conversion efficiencies of the mill sludge were low, possibly due to the use of an early generation enzyme during hydrolysis where the sugars were produced and then fermented to ethanol.

The proposed product of the Fiberight processing in Maine is a concentrated, filtered, clean simple sugar solution for off-site use. Another option involves processing simple sugars from the hydrolyzer in the AD system as soluble organics on-site for additional biogas production. Fiberight claims this is likely the option they will choose during 3 of the winter months in Maine due to the short supply of natural gas in Maine. Both of these alternatives would avoid the technical risk and capital investment associated with the fermentation and upgrading of ethanol. Darrell Waite's report on proposed MSW sugar utilization in Appendix D cautions having sugars as an end product due to lack of market for cellulosic sugars. Fiberight claims they have an interested party for the sugars produced in their plant in Virginia and is looking into the market for the Maine sugars with multiple parties. Transportation of the clean sugars to the end user will need to be evaluated for cost and possible contamination.

Inquiry 1e

## IV. Site infrastructure and permitting needs:

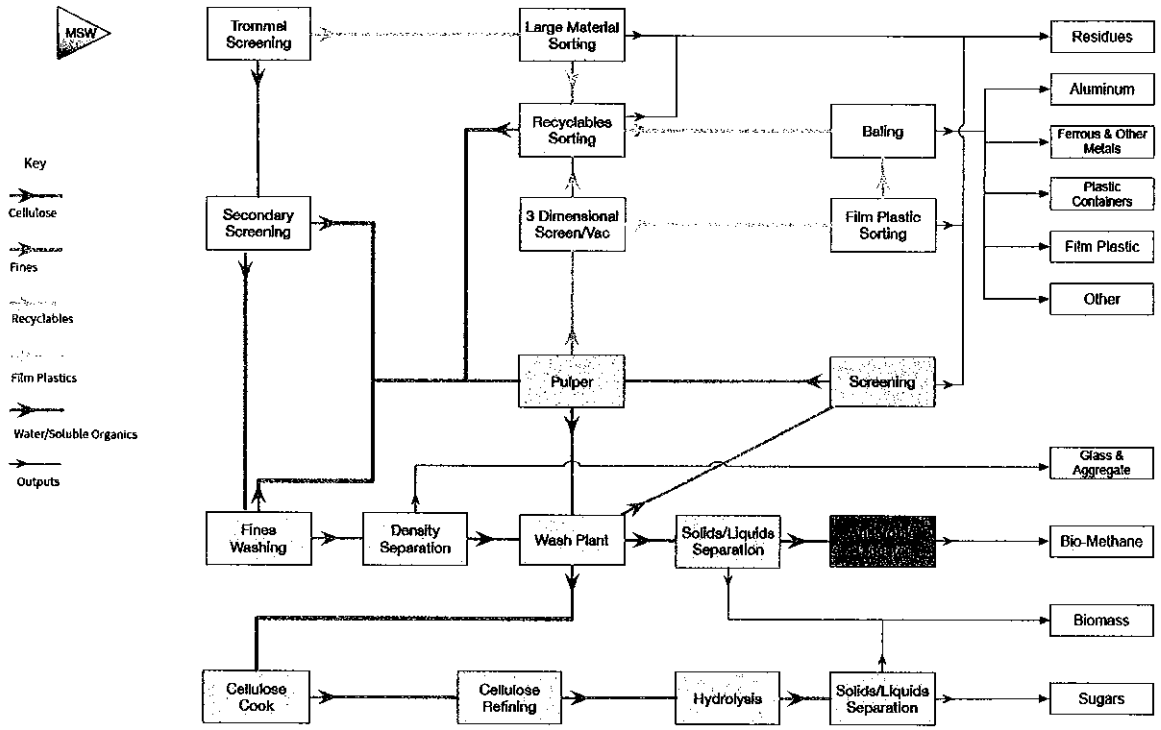
As shown in an overall process flow diagram below (See Appendix A and B for process descriptions), a variety of processing options raise certain site attributes that need to be considered early. The process description supplied by Fiberight does not adequately specify on-site waste water treatment and disposal needs. Furthermore, solid waste disposal to a landfill is also not clearly specified. A full mass and energy balance should be obtained and reviewed because it is needed to fully understand impacts on air, water and landfill as well as process energy requirements. With the elimination of ethanol production from the scope of the Maine project, now there is no product with current established markets in Maine. There appears to be a significant reliance on emerging Maine markets for biomethane produced from AD, sugars produced from hydrolysis, and residual unhydrolyzed biomass. It is unclear what portion will be used onsite versus sold.

Inquiry 3b

Fiberight is exploring the use of paper mill sludge at their Iowa plant. A possibility of accepting pulp or paper mill sludge to supplement MSW derived organics may be an interesting option, but avoidance of current landfilling in favor of transporting sludge to the proposed Fiberight facility combined with on-

going pressure to reduce cellulose losses from mills into waste sludge raises various practical business issues.

A report by Sevee & Maher Engineering, Inc. (SME) in Appendix E offers more information on details of permitting requirements. Once the material and energy balance information is complete along with equipment selection and sizing, the permitting process should begin in order to meet the project deadlines. The permitting process could take an estimated 6 months to one year. As mentioned in the SME report in Appendix E, the Fiberight site proximity to Acadia National Park and Moosehorn Preserve could raise air emissions concerns.




Inquiry 1d

Site selection criteria should include consideration of the following attributes:

1. Access to waste water treatment – industrial preferred or municipal with adequate capacity.
2. Access to natural gas pipeline
3. On-site natural gas usage
4. Good road for truck traffic and rail access
5. Industrially permitted site for air and water emissions and deployment of MSW Organics conversion technologies
6. Distance away from residential and retail zones or other environmentally sensitive areas.
7. Space for co-location with users of recovered materials.
8. Shielded from public view.
9. Pine Tree or other incentivized zone is a plus.

## V. Technology Readiness and Project Implementation Considerations:

Proposed process technology for converting MSW derived organics into biogas and MSW cellulosic sugars has been clearly identified by Fiberight, with several aspects already deployed at pilot or small commercial scale. Processing equipment used for MSW pulping, washing, pretreatment, hydrolysis, and anaerobic digestion at the Fiberight pilot plant in Lawrenceville, VA is sufficiently similar to what has been deployed in pulp and paper industry so that scale up risk is not an issue. Appendix B gives detailed notes from the November 2014 site visit, and Appendix C provides comments on MRC site visit report of December 2013 as an update.

Inquiry 4a

Fiberight has been working with a number of strategic equipment suppliers, including Vickers Seerdrum for a continuous pulper, Milnor for the two-stage washing unit, Andritz for the cooking and refining stages, Proquip for mixing, HydroThane for the EGB (expanded granular bed) reactors for the AD plant, and Novozymes for the enzyme and technical support. These relationships are valuable assets. Fiberight is also working with an independent engineer (Black & Veatch) in connection with an USDA loan guarantee application for the Iowa project. The Independent Engineers report on Fiberight's Iowa project will provide significant information that would useful for evaluating a business case for the proposed project for MRC in Maine. Such a report may contain details on the material and energy balances, along with estimates of CapEx and OpEx, for various process blocks in the Fiberight process flow diagram.

Inquiry 5b

The proposed technology is close to beginning construction for commercial deployment in Iowa, although we have not seen a detailed resource loaded construction schedule with a specific starting date. The next step for the Maine project is to clearly define the scope of the project in terms of the final products and end users/customers. There is still some uncertainty regarding what is going to be used on-site and what is going to be sold and in what form. Once that is defined, there should be a deeper dive for the capital required for process technology implementation. A table showing the DOE[3] Class 5 Concept Screening study is shown in the table below. Based on the fact that the Iowa project is at or near the Class 2 level, there will be many similarities for the Maine project and the planning time should be reduced. It would still require resource commitments on Fiberight's part dedicated to advancing the Maine project. Another planning stage process used for construction projects is Front End Loading and it has 3 levels, of which level 3 is defined below. This will need to be completed to have all basic data/information to file for permits. Once FEL 3 is complete, the permitting will take conservatively 12 months for a greenfield site. Often the permitting needs to be completed before major equipment can be ordered. Major equipment may have lead times as long as 12 - 18 months. As an example, evaporators are typically 15 +/- 3 months for delivery. The major lead time items will drive the schedule. A project completion schedule for startup of operations by April 1, 2018 appears to be aggressive, but still realistic.

Inquiry 2d

[3] https://www.directives.doe.gov/directives-documents/400-series/0413.3-EGuide-21

| | *Primary Characteristic* | *Secondary Characteristic* | | |
|---|---|---|---|---|
| **ESTIMATE CLASS** | **DEGREE OF PROJECT DEFINITION** Expressed as % of complete definition | **END USAGE** Typical purpose of estimate | **METHODOLOGY** Typical estimating method | **EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a] |
| **Class 5** | 0% to 2% | Concept screening | Capacity factored, parametric models, judgment, or analogy | L: -20% to -50%<br>H: +30% to +100% |
| **Class 4** | 1% to 15% | Study or feasibility | Equipment factored or parametric models | L: -15% to -30%<br>H: +20% to +50% |
| **Class 3** | 10% to 40% | Budget authorization or control | Semi-detailed unit costs with assembly level line items | L: -10% to -20%<br>H: +10% to +30% |
| **Class 2** | 30% to 70% | Control or bid/tender | Detailed unit cost with forced detailed take-off | L: -5% to -15%<br>H: +5% to +20% |
| **Class 1** | 70% to 100% | Check estimate or bid/tender | Detailed unit cost with detailed take-off | L: -3% to -10%<br>H: +3% to +15% |

Notes: [a] The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

Front-End Loading (FEL) 3: Project Planning[4]

This stage is referred to as the project planning stage. The beginning of this phase is defined as the point at which one alternative evaluated during FEL 2 has been selected for further definition, with the goal of taking it to an authorization board for funding. During this phase, most project teams grow in size due to the increased amount of engineering work to be completed prior to authorization.

The goal of FEL 3 is to develop a set of engineering documents (design basis package) that incorporate site-specific conditions and a plan for executing the project, such that reliable cost and schedule estimates can be established. Typically at the FEL 3 stage the cost estimates reflect an accuracy of between ±10 to 20 percent accuracy. The product of this phase will allow a detailed package to be presented at the authorization gate. The specific deliverables for the FEL 3 stage are:

- Complete P&IDs
- Detailed Equipment Specification

[4] http://www.ipaglobal.com/Services/Individual-Capital-Project-Services/FEL-3

- Procurement Plan
- Detailed Scope of Work (including quantities)
- Critical-Path Method, Resource-Loaded Schedule (including startup activities)
- Authorization-Grade Estimate (±10 to 20 percent accuracy)

The end of FEL 3 occurs when the project is authorized and the project team receives funding to move into detailed engineering. This corresponds to Class 3 accuracy.

Enquiry 5c An immediate recommendation is that an owner's or lender's representative, similar to what DOE and USDA require for their programs, be secured for the Maine project. This representative should have the capability to complete or review the Front End Loading (FEL 3) process for the Maine project, which is the common capital project process today. This representative should focus on an Independent Engineering Review and Risk Management for the MRC. The timing of this is critical because it is an incremental, cumulative process that builds upon early tasks to complete later, more complicated tasks.

## VI. List of Appendices

A. Fiberight Process Description

B. Notes from visit to Fiberight pilot plant in Lawrenceville, VA Nov. 11, 2014

C. Report on Trip to Fiberight Facility in Virginia with Mike Bilodeau's comments and updates

D. Fiberight Technology Evaluation of Conversion of MSW Organics into Ethanol

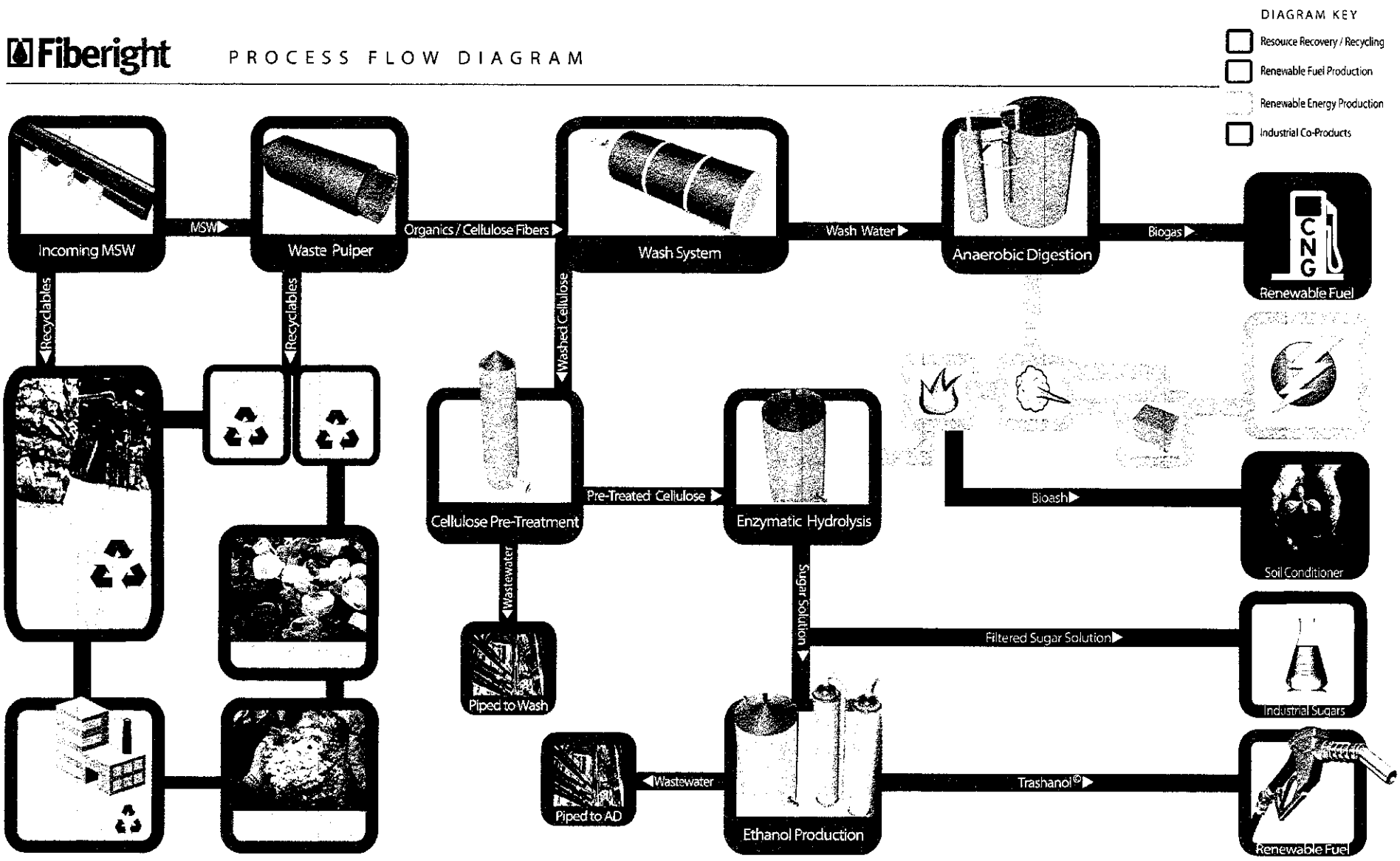
E. Site Infrastructure and Permitting Considerations

# APPENDIX A

"Fiberight Process Description", Memo to Karen Knuuti, Maine DEP Regional Office, from Municipal Review Committee, September 26, 2014, pgs. 4-8.

Fiberight

# PROCESS FLOW DIAGRAM



## PROCESS DESCRIPTION

### MSW Receiving

#### Primary MRF

The first step in the process is to remove large bulky items prior to MSW loading into a low torque shredder which opens and empties bags of trash. MSW is conveyed through a series of screens to create different size fractions. Materials larger than 14 inches continue on to be hand sorted for recycling or disposal.

#### Pulping

The sorted material is conveyed into a drum pulper which breaks the organic material down to form a biomass and allows for the removal of any fine contamination, the recovery of soluble organics and resulting cellulosic pulp. Pulped material is discharged, as a high moisture solid and passes across a screen to recover recyclables such as metals and plastics. The remaining biomass, approximately 80%, still containing fine contaminants and soluble organic material, is conveyed to the washing system.

##### Plastics processing

The plastics recovered post-pulping is first separated into a mixed plastic stream and then further separated into individual plastic streams. These steams are shredded and go through a washing process where residual contaminates are removed. The final stage is to "flake" and dry each of the plastics to produce a product suitable for reprocessing, commanding a higher price per ton than marketing the plastics as received.

#### Washing

The homogeneous organic fiber is conveyed into a two stage washing process. This a continuous process utilizing a series of drums and screens to contaminants and concentrate the organic fraction. The first stage wash removes soluble organic material and pumps the high chemical oxygen demand wastewater to a pre-acidification tank prior to entering the high-rate anaerobic digester for biogas production. The second stage wash dilutes the remaining material where filters are used to separate out the fine cellulose from the remaining contaminates. The washed cellulose is then pumped into a stock tank. From the stock tank, the cellulosic pulp is pumped as a slurry into a screw press where it is de-watered to about a 50% solids press cake. Washed fibers exit the system and are pumped to be pre-treated for hydrolysis.

### Enzymatic Hydrolysis

#### Pretreatment Reactor

The dewatered pulp is conveyed to the pretreatment reactor whereby water and acid is added into a pretreatment mixer so the appropriate solids concentration and pH is obtained. Slurry from the pre-treatment mixer is then pumped to pre-treatment reactor and held at

approximately 125°C for a minimum of 30 minutes. Fiber exiting the pretreatment reactor is pumped to a medium consistency refiner and then to a screw press to be dewatered. The filtrate from the screw press is returned to the mix tank. The pretreated fiber press cake is conveyed to an enzymatic hydrolysis digester. The pretreatment reactor, pumps, filtrate tank, and screw press are connected to a Clean-in-Place (CIP) system for regular cleaning and sterilization.

**Hydrolysis**

The hydrolysis process is carried out in within a high viscosity digester paired with a set of mixing tanks. The pre-treated fibers enter the mixing tanks along with water and enzymes. The enzymes, produced by Novozymes (our strategic partner - ***novozymes***.*com*) help break the cellulose bonds to produce C6 and C5 sugars. Fiberight has developed intellectual capital to maximize cellulose to sugar conversion efficiency and lower enzyme costs, the most expensive component of ethanol manufacturing costs. The wetted fibers circulate through the hydrolysis tank where cellulose within the fiber is converted to sugars on a batch basis. The temperature of the process is controlled for optimum digestion and the pH is controlled by adding either acid or alkali, as required. Once the optimum mixture is obtained, it is left in the digester where the low-temperature biological process is complete. Each digester, pump, heat exchanger and mixing vessel are connected to a CIP system for regular cleaning and sterilization.

**Solids Separation and Sugar Concentration**

A filter press is utilized to separate the undigested solids from the liquid sugar solution. The undigested solids are slurried and passed to the water treatment plant. The sugar solution is pumped to an evaporator where it is concentrated for storage. The condensate recovered from the evaporator is stored and used as make-up water for the digestion process. The pumps and tanks are connected to a CIP system for routine cleaning and sterilization. The filter press membrane system is a skid mounted vendor system that incorporates a clean-in-place feature.

**Renewable Energy Production**

**Anaerobic Digester**

The high organically loaded liquid is cooled and sent to an anaerobic digestion system. This system uses microorganisms to digest suspended and dissolved solids contained in the water to reduce the chemical oxygen demand (COD) of the water. The conversion efficiency of this process and the high soluble organic loading produces clean water which can be reused in the washing process and does not generate digestate. A methane-rich biogas stream is also produced, which can be used as supplementary fuel for internal energy production via a boiler, cleaned and compressed for use in CNG vehicles or injected into a natural gas pipeline.

**Recovered Water & Clean-in-Place**

Process water recovered from the water treatment system is used to dilute solids in the pulp and wash systems to maintain desired moisture content. A portion of the recovered water is sent to the CIP storage tank. Sodium hydroxide (caustic) is added to the water in this tank to produce a cleaning solution. The caustic CIP solution is circulated to and through equipment to remove accumulated solids and to sterilize equipment to prevent the growth of bacteria. Cleaning frequency is based on equipment type and plant / production performance.

**Biomass Combustion**

The solids from the water treatment plant, which is spent fiber with a high lignin content, are processed in a specially designed combustion unit. The heat from the combustion process is recovered, in the form of high pressure steam, which is let down through a back pressure steam turbine. The exhaust steam from the turbine is then used to provide process heat. The amount of electrical and heat energy generated by the biomass combustion is sufficient to provide the energy demand for the plant.

**Renewable Fuel Production**

**Fermentation**

The C6 and C5 sugars are used to produce cellulosic ethanol through a fermentation process. Once the concentrated sugar solution is cooled to 33°C (the temperature for fermentation), fermentation is accomplished in three tanks, all of equal size. The fermentation process generates heat, which is removed by circulating the tank contents through external heat exchangers. The fermenters are piped to circulation pumps and coolers for cooling and transferring the beer, the liquid resulting from fermentation, to the beer well, a holding tank that continuously feeds the distillation system.

The carbon dioxide ($CO_2$) that is produced during fermentation is collected and routed to a scrubber. Residual ethanol is recovered by the scrubber and the resulting carbon dioxide gas can be recovered and sold as food-grade $CO_2$. The fermenter tanks, pumps, and heat exchangers are connected to a CIP system for regular cleaning and sterilization.

**Distillation and Dehydration**

The distillation system separates the ethanol in the beer from the remaining water and solids. The beer is preheated using the hot bottoms from a rectifying column. The solids and a portion of the water exit the bottom of the column. This stream, commonly called "stillage," is partially cooled by preheating the beer and sent to the water treatment system. The ethanol vapor is concentrated as it rises through the column eventually reaching the azeotropic point (95.5 % v/v) as it exits the top of the column. A portion of the column overheads are condensed and returned to the column as reflux. The remaining part of the concentrated ethanol is then fed to the dehydration system.

To produce fuel grade ethanol, the remaining water must be removed. This is done utilizing a two-bed molecular sieve dehydration system. Water is adsorbed on the sieve bed material while ethanol passes through the bed. The dehydration system uses a "pressure swing" process that requires virtually no external heat. Each of the sieve beds cycles between adsorption and regeneration modes to maintain maximum water removal capacity. Adsorption takes place under positive pressure while regeneration is accomplished under vacuum. The adsorbed water is removed during a regeneration step and is routed back to the distillation system.

**Fuel Ethanol Storage and Loading**

Cellulosic ethanol is pumped to one of two shift tanks, each sized to store 24 hours of production at the full plant design production rate. The production rate of the ethanol from the distillation / dehydration system is monitored with in-line instrumentation, while moisture content is monitored with laboratory equipment from regularly scheduled samples. Once ethanol quality is verified it is transferred to a product storage tank. A blending system is used to blend gasoline denaturant from a denaturant storage tank into the ethanol as it transfers to a product storage tank. The product storage tank stores four days of ethanol production. The capability to add additional denaturant in-line before the truck load-out is also provided. A loading system is provided to allow the drivers to load their own trucks with minimal assistance from plant operators. One loading arm, with a 600 gallons per minute loading capacity, is provided. Trucks are bottom filled. Vapor displaced during the filling process is burned in a flare or vented to the atmosphere in accordance with environmental permits.

**Plant Water Management**

**Recycling & Reuse**

Purge water from the washing system, diluted solids from the sugar recovery and the stillage from distillation are blended together. The solids are removed using a belt press and any residual fine suspended material is removed using a dissolved air flotation system. The high organic liquid created is sent to the anaerobic digester. The solids, in the form of cake, are sent to the biomass combustion plant.

# APPENDIX B

"Notes from visit to Fiberight pilot plant in Lawrenceville, VA Nov. 11, 2014", Michael Bilodeau, December 10, 2014.

**Process Development Center**
*Department of Chemical and Biological Engineering*

THE UNIVERSITY OF MAINE

5737 Jenness Hall
Orono, Maine 04469-5737
*Tel.: 207-581-2387*
*Fax: 207-581-4174*
*www.umche.maine.edu/pilot*

December 10, 2014

**Subject: Notes from visit to Fiberight pilot plant in Lawerenceville, VA Nov. 11, 2014**

The following are notes from my visit to the Fiberight pilot plant in Lawerenceville, VA on November 11, 2014. Nick Thompson, Fiberight CTO, hosted the visit and provided responses to questions and other information contained in this memo.

Inquiry 4b

The pilot plant is located in a separate building on an industrial lot on the outskirts of a rural town. The plant can process 50 tpd of municipal solid waste (MSW). Some of the feedstock for the current campaign was stored outside during my visit.

**Front End**

Unit operations at the Fiberight pilot plant can be arranged in such a way that MSW can be processed, in a batch mode, to simulate some of the process flows proposed for commercial facilities, such as the one in Maine. Some equipment is used twice to simulate the proposed process. For example, one set of screens and conveyors are used to process the in-coming raw material (MSW) in an initial fractionation step. The same screens are subsequently used to fractionate the material leaving the autoclave in a second pass. While not uncommon for a pilot facility, it does limit the ability to simulate a continuous process at the pilot plant scale.

**Autoclave (Pulper)**

The key to the Fiberight process is the low "cooking" temperature sorted MSW is processed at in the autoclave, or pulper. Typically, the autoclave operates at 70-80 C. for up to one hour. The temperature is held low enough as to not melt or degrade the plastics that are to be recovered, yet high enough to sterilize the material. The low temperature ensures that the plastic fraction is not degraded, preserving the value of the recovered plastic and makes the separation process more efficient. Sufficient water must be used to fully hydrate the fibers which aids in fiber recovery.

The output from the Autoclave goes to a screen where the fiber is sent to the washers and the larger plastics, metal and glass are sorted from the stream.

**Washing**

Inquiry 4a

The fiber washing step uses a continuous, multi-stage process, similar to a cruise ship clothes washing line. Wash water goes to AD, solids go to a screen and then on to the refiner. Refining of the fiber improves enzyme conversion efficiency.

The refined fiber is then heated with steam and thickened in a screw press.

Phosphoric acid is added to the material exiting the screw press and just prior to entering the hydrolysis reactor for pH control. The use of phosphoric acid minimizes the

dissolution of any calcium carbonate present in the fiber faction and, unlike sulfuric acid, does not form gypsum which is difficult to process. The pH is buffered at approximately 5.2-5.5 and provides for improved pH control compared to stronger acids such as hydrochloric or sulfuric acid.

Andritz is the technology partner for the pulper, washer and refiner.

**Hydrolysis**

Inquiry 1f

The hydrolysis is carried out in a 1500 gallon fed batch reactor at 55 C and a pH of 5.5. Some ammonia can be added to control pH. Suspended solids are about 12%, but can be as high as 20%. Proper mixing is challenging at the higher solids/viscosity.

The hydrolysis reactor is front end loaded with enzyme and fed continuously during the hydroysis.

Inquiry 4c

Fiberight achieves about 40% hydrolysis conversion, on a solids basis – 50% conversion based on carbohydrates. The hydrolysis reaction takes between 60 -72 hours to complete.

Enzyme efficiency with CTech3 is about 0.07 kg enzyme/kg of sugar. Novazyme anticipates that this will improve by 25% when they begin to use CTech4. Fiberright reports that the sugar out of the hydrolysis stage contains "very little" lactic acid or other inhibitors. No data on the sugar purity was made available. Sugar concentration out of the hydrolysis reactor is about 6-7%, with a composition of 20% C5 and 80% C6.

Inquiry 1h

Inquiry 1g

Fiberight is interested in improving refiner control for hydrolysis improvement. They are interested in exploring moving the refiner to process the isolated hydrolysate solids leaving the hydrolysis reactor. The processed solids are added to the next hydrolysis reaction. This is expected to provide refiner energy savings and improved enzyme efficiency.

The output from the hydrolysis reactor goes to a plate and frame press. Filter cake solids are about 40% with about 10% sugar losses. Some of these losses are recovered in subsequent passes through the hydrolysis reactor as the solids are fed back to the reactor.

The recovered sugars would be sent off to fermentation or concentrated and sold.

**Outputs and Sugar Conversion**

Inquiry 4e
Inquiry 5d

The pilot plant does not have any fermentation or ethanol processing capability. The inability to secure an environmental permit to produce ethanol for the site has contributed to this situation. Thus, no assessment in the ability to ferment the sugars into ethanol at the pilot scale could be made.

Currently, C6-rich sugars isolated from the hydrolysis reactor are combined with the C5-rich sugars streams and then sent to the anaerobic digester (AD) to produce biogas. The biogas produced in the AD is flared.

Novazyme is the technology partner for enzymes and fermentaton. They have

fermented the Fiberight sugars into ethanol, but only at the bench scale. The fermentation model is based on C6 conversion only.

In commercial operations, it is expected that enough centrifuge solids (@ 24-25 MJ/kg, primarily lignin), and plastics-rich rejects are generated to satisfy the steam and electrical requirements for a plant producing ethanol. The biogas generated would be an additional revenue stream.

The AD needs to be started with "starter seed water" from another operating AD reactor. The AD reactor is "self-sufficient" after start-up. Voith is the current technology partner for the AD, which is a "high capacity", liquid only digester.

Typically, as much as 20% of the MSW raw material is not able to be processed (such as furniture, mattresses, large toys, etc) and would need to be land filled.

Very little, if any, process water is discharged from the process. Fresh water is needed for steam generation (boiler quality water) and to start the hydrolysis reactor on start-ups. All other operations reuse process water.

**Other**

The Blairstown, Iowa plant is scheduled to start construction soon, with start-up expected in late 2015. The plant will use 650 tpd of MSW and plans to supplement the feedstock with 350 tpd of paper mill sludge. One of the paper mills is an IP mill. They have not yet run paper mill sludge in the pilot plant.

Fiberight secured an USDA Loan Guarantee for the IA project. Black & Veatch is the independent engineer on the project and expects to issue their report in Feb 2015. The loan is expected to close in June 2015.

The core technology is sugar production. Fiberight is working with a company on take-off agreements for sugar. The final product/application was not disclosed.

Fiberight expects to build and operate the ME plant. Break-even scale is 250 tpd of MSW. Fiberight claims that the current economic model doesn't work with a tipping fee of 0$/ton, but if plastic film could be sold, then plant would operate in the black.

Sincerely,

Michael A. Bilodeau
*Director, Process Development Center*
mbilodeau@maine.edu

# APPENDIX C

"Report on Trip to Fiberight Facility in Virginia", Greg Lounder and George Aronson, 19 December, 2013, with comments added by Michael Bilodeau, December 22, 2014.

# *MEMORANDUM*

TO: MRC Board of Directors
FROM: Greg Lounder, Executive Director, MRC
George Aronson, Principal, CRMC
RE: Report on Trip to Fiberight Facility in Virginia
DATE: 19 December 2013

This memorandum describes the trip to the Fiberight MSW processing facility in Lawrenceville, Virginia, which was visited by MRC Board Chair Chip Reeves and MRC executive director Greg Lounder and consultant George Aronson on December 18, 2013.

The Fiberight Facility is a pilot project that was recently upgraded to a demonstration scale in order to demonstrate a process for converting MSW into ethanol and other fuels or chemicals. Inquiry 46 At present, the facility accepts about five tons of MSW every two days. The MSW is solicited from local towns or haulers on an on-call basis. The facility includes four components:

1. A dirty MRF for recycling easily recoverable components of incoming MSW.
2. A pulp and wash plant for converting the organic components of incoming MSW into pulp.
3. A chemical plant for converting the pulp into ethanol or other products.
4. An anaerobic digestion plant for converting slurried organics into bio-gas.

**The MRF**

When received, the MSW is off-loaded into a bunker (Figure 1), then pushed onto an inclined conveyor that feeds a trommel with a bag-opener and screens with 2.5-inch holes (Figure 2). Materials that pass through the trommel ("overs") are sent to a picking line for removal of large textiles (Figure 3) and other non-processibles, then stockpiled in a bunker near the autoclave. Materials that fall through the holes in the trommel screen ("unders") are sent through a second trommel having 0.75-inch holes. The overs from the second trommel (which do not contain any large textiles) are also sent to the bunker near the autoclave. The unders from the second trommel screen, which consist mostly of dirt, sand and stones, are sent to a landfill.

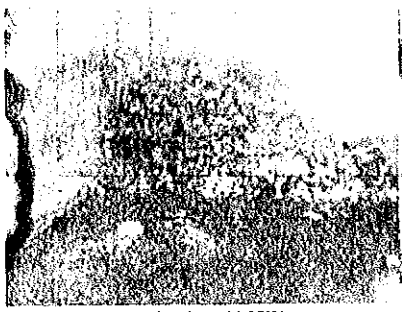


Figure 1. Bunker for tipped MSW.

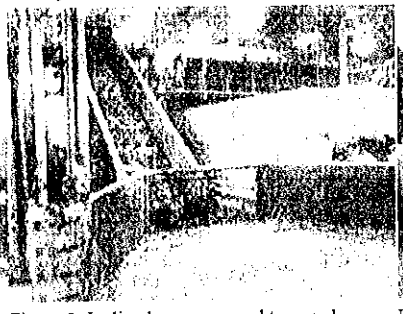


Figure 2. Inclined conveyor and trommel.

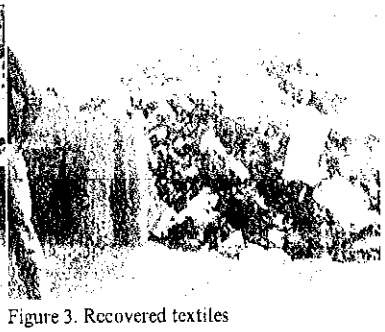


Figure 3. Recovered textiles

The autoclave (Figure 4) is loaded with material in 1000-pound batches, then mixed with 100 gallons of water per batch. Each batch is mixed and heated for 45 minutes at 23[1] grees F. The autoclave acts as a high-solids pulper that solubilizes the organic waste and turns the paper to fiber, but does not depolymerize the plastic. Material leaves the autoclave having absorbed the added water to reach a moisture content on the order of 70 percent (Figure 5). This material is then pushed onto the same in-feed conveyor used on the raw MSW to the same trommel with screens having 2.5-inch holes referenced previously [a new plant would have separate conveyors and trommels]. The trommel overs are sent to the picking station for manual recovery of plastics and metals (Figures 6 and 7) [A new plant would use automation to recover plastics, ferrous and non-ferrous metals, and might recover other materials]. The trommel unders consist almost entirely of organics and fibers that are sent to the pulp and wash plant.

Figure 4. The autoclave.

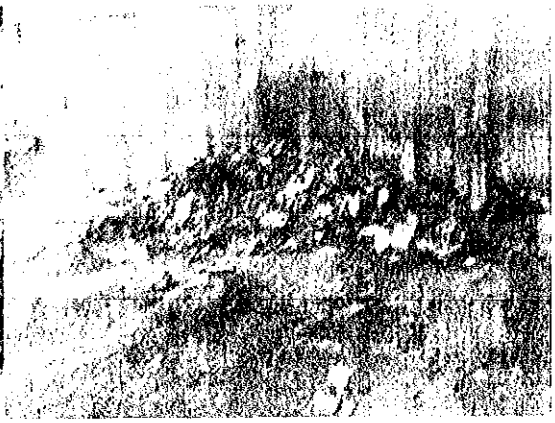


Figure 5. Autoclaved materials.

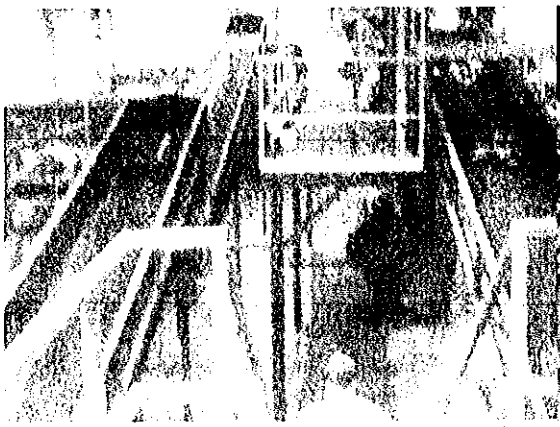


Figure 6. Pulped organics and recyclables leaving the trommel.

Figure 7. Recovered plastics.

**The Pulp and Wash Plant**

The pulp and wash plant involves use of a "continuous batch washer" (Figures 8 and 9) to produce clean sterilized pulp from the incoming materials. Materials are agitated and sterilized in multiple stages for 35-minute cycles at 25[1] grees Fahrenheit. The pulp and wash plant also includes an elaborate scheme for recycling incoming water and for minimizing water and energy use through counter-flow configurations, as well as elaborate systems for de-watering and removing entrained plastics from the pulp.

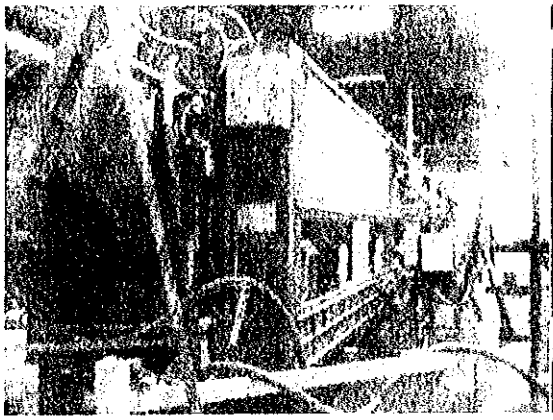


Figure 8. The continuous batch washer.

Figure 9. The continuous batch washer.

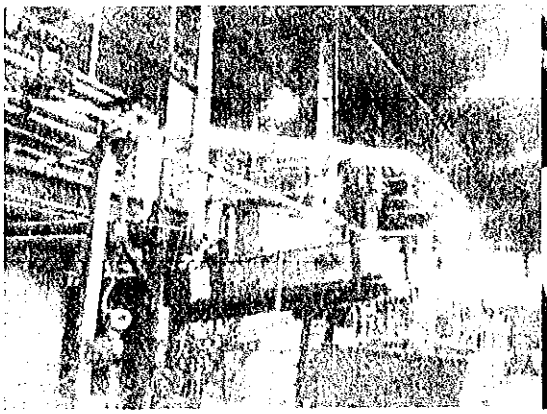


Figure 10. De-watering and plastics removal systems.

Figure 11. Clean pulp made from MSW.

**The Chemical Plant**

Iquiry 5d The chemical plant includes elaborate processes for adding enzymes to the pulp, adjusting pH, and controlling mixing and temperature to create sugars, encourage fermentation and create ethanol and various other products (Figures 12 and 13). Fiberight is selling the ethanol to fuel blenders for $1.80 per gallon, which translates to $32.40 per ton of incoming MSW at a production rate of 18 gallons of ethanol per ton of MSW. Fiberight continues to experiment with

# Summary of Comments on MRC memo_001 mab comments 12 22 2014.pdf

## Page: 2

Number: 1 Author: mbilodeau Subject: Sticky Note Date: 12/22/2014 10:29:55 AM

They have since gone to low temp cooks to preserve plastic value and not melt materials.

the process to demonstrate the types of products that can be created and the optimum methods for production. Among the products that are generated is a residual material stream from the conversion process referred to as "post-hydrolysis solids" (Figure 14), which Fiberight indicated had sufficient energy value to be pelletized for use as a solid fuel, and sufficient nutrient value to be blended with compost.

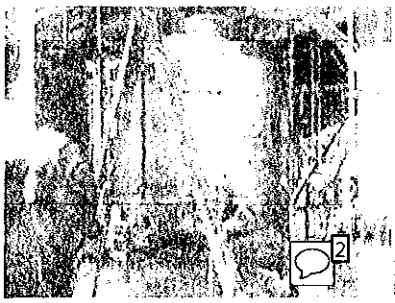


Figure 12. Fermentation in the chemical plant.

Figure 13. Ethanol production.

Figure 14. Post-hydrolysis solids.

Inquiry 5d

**The Anaerobic Digestion (AD) Plant**

The AD plant is used to digest a liquid wastewater from the continuous batch washer that is laden with organic material from the pulp and wash plant. The AD plant is a low-solids reactor vessel that has an 8-hour residence time for COD destruction. The AD plant produces bio-gas, which is destroyed in a flare.

**Status of Technology Development**

Fiberight is using the results of its experience at the Lawrenceville facility as the basis for developing a set of facilities in Iowa. Fiberight already owns a small chemical plant for producing ethanol from biomass in Blairstown, Iowa. Fiberight is about to start construction on a commercial 650 tons-per-day facility in Marion, Iowa (near Cedar Rapids), that would include a mixed MSW MRF and a pulp and wash plant. The pulp would be sent to the Blairstown facility for conversion to ethanol. Fiberight has also been selected for development of a facility in Iowa City, Iowa, that would accept mixed MSW, remove non-processibles, then transfer the material to the Marion facility for processing. As part of the agreement, Iowa City would discontinue its curbside recycling collection program on the assumption that all of the recyclable material would be recovered either at the Iowa City mixed MSW MRF and transfer station or at the Marion processing facility.

Fiberight is familiar with RDF from the PERC facility. During the development of the Lawrenceville facility (before it was taking MSW), Fiberight arranged to receive several loads of RDF from the PERC facility. The RDF was processed, autoclaved and washed at the

Number: 1 Author: mbilodeau Subject: Sticky Note Date: 12/22/2014 10:36:59 AM

I did not see pressurized vessels in the equipment that I saw.

# Page: 4

Number: 1 Author: mbilodeau Subject: Sticky Note Date: 12/22/2014 10:40:47 AM

There are a series of tanks on site. These could be used for fermentation but we not during my visit. Some contained recycled process water and they were working on managing volumes to run "continuously".

Number: 2 Author: mbilodeau Subject: Sticky Note Date: 12/22/2014 10:38:24 AM

hydrolysis tank

Number: 3 Author: mbilodeau Subject: Sticky Note Date: 12/22/2014 10:43:48 AM

They were processing both wash water and recovered sugars to the AD when I visited. Voith is their partner for AD technology.

Number: 4 Author: mbilodeau Subject: Sticky Note Date: 12/22/2014 10:49:19 AM

We did not review this capability during my visit.

Number: 5 Author: mbilodeau Subject: Sticky Note Date: 12/22/2014 10:46:59 AM

I incorrectly identified the site as Blairsville in my report.

Lawrenceville facility, put into 40-pound bags, then shipped to the Blairstown, Iowa, facility for conversion to fuel-grade ethanol. Fiberight reported that the RDF from PERC was converted to ethanol successfully.

**Evaluation**

The Fiberight facility warrants significant additional evaluation for consideration by the MRC. Fiberight's technology concept for MSW management has been demonstrated at both a pilot and demonstration level, and Fiberight is close to starting construction on a full-scale commercial facility using the technology in Iowa. The Lawrenceville facility is actively recovering and marketing recyclable materials from mixed MSW, and is producing a high-value liquid fuel product from MS[1]The scale and type of the facility appear to be consistent with the needs of the MRC communities. Moreover, Fiberight has expressed interest in developing a facility in Maine, which would be consistent with its own roll-out plan for pursuing opportunities along the East Coast. Finally, one of the key investors in Fiberight is Cate Street Capit[2]hich owns and operates the Millinocket paper mill and has a strong presence and an active interest in facility development and operations in Maine.

The next steps in investigating the opportunity include the following:

- Get more information on potential facility mass and energy balances, capital costs, operating costs, revenues and tip fee requirements. Fiberight has offered to provide a conceptual pro forma that could be the basis for the next level of economic evaluation by the MRC.
- Confirm the requirements for a site for the facility, including site area, building dimensions and infrastructure requirements (e.g., electric, natural gas, water and sewer services).
- Evaluate the feasibility of marketing ethanol or other products in the form produced by the facility to purchasers located in Maine or otherwise within reasonable transportation distance of the facility.
- Evaluate the MRC's preferences regarding business arrangements with Fiberight as the developer of an emerging technology, as well as the MRC's preferred approach to procurement and selection of a specific technology and vendor.
- Evaluate the alternatives to Fiberight for organics management, including anaerobic digestion alternatives (e.g., as proposed in the responses to the RFEI by Orgaworld, Mustang, RRT, Vecoplan and Van Dyk).

# Page: 5

Number: 1 Author: mbilodeau Subject: Sticky Note Date: 12/22/2014 10:51:46 AM
could be out of the Blairtown facility, but I didn't see this capability during my visit to the VA pilot plant.

Number: 2 Author: mbilodeau Subject: Sticky Note Date: 12/22/2014 10:52:05 AM
was not mentioned to me...

# APPENDIX D

"Fiberight Technology Evaluation of Conversion of MSW Organics into Ethanol", Darrell Waite, December 26, 2014.

December 26, 2014

TO: Hemant Pendse; Director, FBRI University of Maine

FROM: Darrell Waite; Formerly Process Manager, Biorefinery and Director of Technology, Old Town Fuel and Fiber, Old Town, ME

SUBJECT: Fiberight Technology Evaluation of Conversion of MSW Organics into Ethanol

The Fiberight technology was evaluated for economic feasibility based on pilot data and process information provided directly by Fiberight. This summary is based on a comparison of several years of woody biomass to sugar to ethanol technology development completed by the Biorefinery team at Old Town Fuel and Fiber (OTFF) in partnership with the University of Maine FBRI. The following evaluation is preliminary in nature and should be considered FEL1 level (+/- 50%).

The primary focus in this portion of the overall evaluation was the organic component conversion of the MSW. The Fiberight technology will utilize the organic portion of the MSW to convert to C6 rich sugars which will either be sold as cellulosic sugar on the open sugar market, used to produce cellulosic ethanol or used to produce higher value bio-products.

Inquiry 1e

OTFF, along with the U.S. Department of Energy (DOE), investigated the potential of selling cellulosic sugar on the sugar market. There were several issues that led OTFF and DOE to conclude that this was not a viable option. These issues included the lack of a current cellulosic sugar market, the expensive and time consuming requirement to create this market, the impracticality of competing with the global sugar markets, and the expense of drying the sugar to minimize shipping costs. DOE would be willing to share their experience in this matter as the work they completed is in the public domain.

The Fiberight data and feedback does suggest that their technology can convert the organic portion of the MSW into two sugar rich streams. The first is a C5 rich stream, which is liquid and goes to an AD where it is converted into Biogas. The second stream is a cellulose rich stream that is deconstructed to a C6 rich sugar stream. This C6 rich stream is the stream we focus on here.

Based on feedback from Fiberight, effective yield is very low probably due to low enzymatic conversion of cellulose/hemicellulose to sugars. This is an area that will need significant improvement, as enzyme cost will be the major cost component in conversion to sugar.

Inquiry 2a

One important note on the mass balance is that when the by-products (plastics, metals, glass and rigid plastics) are added together with the amount of sugar, there is still approximately two thirds of the total mass unaccounted for. This should be further explored and may be easily explained by Fiberight.

Iquiry 2b

Fiberight data on conversion of MSW derived sugar conversion to ethanol was much lower than both woody biomass derived sugars and corn dextrose. This suggests that a high level of inhibitors may be present in the MSW sugar that may diminish ethanol conversion efficiency. Further investigation should be completed to determine if it economically feasible to further

clean up these MSW sugar prior to fermentation.

Scale up concerns could be caused by these inhibitors (possible contamination) in the MSW sugar fermentation. Fermentation stability could be jeopardized. One thought to minimize this risk should be to complete systematic pilot scale testing utilizing MSW derived sugars to produce ethanol, possibly have smaller fermenters, aggressive CIP systems and aggressive SOP's to counter the potential contamination.

A Greenfield site for this type of process will be a major challenge. The need for MSW receiving, sorting, organic cooking, organic solid/liquid separation, liquid C5 rich conversion to biogas via AD and conversion of the solid organic stream to C6 rich sugar to ethanol is a complicated process requiring an energy platform, water intake, water treatment and all supporting equipment and systems. To simplify the process, one option to consider is eliminating the sugar conversion to ethanol portion of the overall process and forward all liquid sugar to the AD. This would reduce a major portion of capital outlay and may be more efficient overall.

Inquiry 2d It is my opinion this technology is 3 – 5 years from ***beginning*** commercial deployment. The next step should be a deeper dive for the capital required for process technology implementation. A FEL1 engineering study should be completed to determine the extent of the capital outlay and determine if the process is economically feasible.

An immediate recommendation is that an owner's representative, similar to what DOE and USDA requires for their programs, be secured. This representative should have the capability to complete the Front End Loading (FEL) process, which is the common capital project process today. This representative should focus on an Independent Engineering Review and provide Project Development Services to the owner. The timing of this is critical because it is an incremental, cumulative process that builds upon early tasks to complete later, more complicated tasks.

Darrell Waite

Formerly Process Manager, Biorefinery and Director of Technology, Old Town Fuel and Fiber, Old Town, ME

# APPENDIX E

"Site Infrastructure and Permitting Considerations", James S. Atwell, P. E. of Sevee & Maher Engineers, Inc., December 29, 2014.

SITE INFRASTRUCTURE AND PERMITTING CONSIDERATIONS
FIBERIGHT TECHNOLOGY
December 29, 2014

## GENERAL

The available information on the Fiberight facility to be built in Maine is very limited. We do not have a detailed process flow diagram or a materials balance that is necessary to estimate the air, solid waste and wastewater emissions from the proposed facility. Therefore, it is not possible to reach definitive conclusions regarding the specific permitting requirements that might be necessary for a full scale Fiberight facility to serve the MRC communities.

However, based on a review of available information and an understanding of the approximate scale of the proposed facility, we do not see any factors that would prevent the permitting of the Fiberight technology at a site in Maine. However, any solid waste facility of this scale would be expected to undergo a comprehensive permitting process that would address the siting of the facility as well as its liquid, solid and gaseous emissions.

Permitting the Fiberight facility will involve several units within the Maine Department of Environmental Protection (MEDEP). For that reason, a pre-application meeting should be scheduled with MEDEP to review the permitting process and to identify the MEDEP team that will process the application and interact with the applicant.

Following are: 1) a summary of the advantages and disadvantages of a brownfields site compared to a greenfields site for the Fiberight facility and 2) a summary of the permits that would be reasonably anticipated for a Fiberight facility.

## BROWNFIELD VS GREENFIELD

Inquiry 2c

Brownfield sites offer potential advantages over a greenfield sites; based on existing permits and available infrastructure for power, and wastewater treatment. These factors have the potential to simplify the permitting process and to reduce the capital cost of the facility. It is also recognized that local, community issues could make it difficult to construct the Fiberight facility at a brownfield site. However, potential brownfield sites should be considered as part of the facility siting process.

## PERMITTING

Following is a list of the permits that will likely be required for the proposed Fiberight facility. Based on our review and understanding of the proposed Fiberight technology, there do not appear to be any environmental or emission issues that would prevent the permitting of the facility, provided the required exhibits can be provided.

However, permitting the facility would involve a comprehensive process with many issues to be addressed. Permitting the Fiberight technology will require detailed information on the character of the air, wastewater and solid wastes emissions from the facility. Because there is no long term operating information on systems that use the Fiberight technology on municipal solid waste (MSW), the local and state permitting agencies are likely to conduct a detailed analysis of the processes to be certain that the estimated emissions are accurate. Past experience has shown that the variable character of the MSW stream and the presence of a broad range of

impurities, makes cost effective operation of these systems difficult. The absence of long term operating information on these processes may extend the duration of the permitting process.

Following is a summary of the primary permits that will be required for the Fiberight Facility.

Solid Waste. The Fiberight facility would require a permit under Maine's Solid Waste Rules, Chapter 400 (General Provisions) and Chapter 409 for Solid Waste Processing Facilities, which are administered by the Maine Department of Environmental Protection (MEDEP). This is a comprehensive permit that incorporates many of the requirements of Maine's Site Location Law. The Solid Waste permitting process would require detailed information on each of the "unit processes" included in Fiberight's system. The permit applicant will also have to address general licensing criteria, such as the following:

- Financial and technical ability to construct and operate the project.
- Must control nuisance odor.
- Cannot be located within 10,000 feet of an airport.
- Annual reporting requirements.
- Consistency with the Solid Waste Management Hierarchy.

MEDEP will look at the Fiberight technology as a Box, with waste materials as the feedstock. They will expect to see a comprehensive description of the outputs from the Process, including: recycled materials, Wastewater Emissions, Air Emissions, Solid Waste, and Hazardous Waste. Each waste stream will require characterization. The characterization will define the specific treatment, disposal and permitting requirements.

The Solid Waste Permit will require that a demonstration that: a) applicable federal, state and local permits are in place and b) final provisions are in place for the disposal/management of facility emissions (wastewater, solid waste, hazardous waste, recycled materials).

Inquiry 1i By-Products/Wastes. Information provided by Fiberight seems to indicate that the process is self-contained and that there are no by-products that must be managed. However, without/ detailed process flow diagrams and a mass balance, it is not possible to confirm these claims.

Based on past experience with similar processes, there are several points in the Fiberight technology where byproducts, or waste materials, are expected to be produced that would require treatment and or management. For example:

- Inquiry 3c Liquids from the unit processes, as well as liquids/wastewater from general washdowns will require treatment. Even though Fiberight indicates that wastewater emissions would be low, or non-existent, our experience is that impurities build up in the system over time and these impurities must be purged from the system. This liquid waste would require some form of treatment, and would have to be considered in the permitting process.
- Waste solids that have no value to the process and are rejected by the system, throughout the process (waste pulperand associated recovery operations, and microorgainisms in the anaerobic digester), will have to be characterized for disposal.

Wastewater. Assuming that there will be some liquid waste produced by the Fiberight technology, some provision for treatment/management will be required. Specific requirements cannot be determined without more detailed information on the quantity and character of the wastewater.

If the plant in Hampden transports wastewater to a Publicly Owned Treatment Works (POTW), the wastewater will have to be characterized, pre-treatment requirements (local limits) will have to be met, and a permit from POTW community will be required.

Air Permit. Although we have no knowledge regarding potential emissions from the Fiberight technology, the facility will likely require an Air Permit issued by the MEDEP. Even if the waste processing portion of the facility does not exceed air permit threshold limits, the power generation portion of the project may require an air permit. Based on the estimated emissions from the facility, a determination will be made to determine if the facility would be permitted as Major Source under Chapter 115 (and related Federal Regulations). If certain thresholds are met, it may also be necessary purchase emission offsets for NOx, VOCs, PM10 and CO.

Depending on the level of emissions and the location of the facility, air permitting issues associated with the proximity of the plant to Acadia National Park and the Moosehorn Preserve, could arise.

Site Location of Development Law (SLODA) and Stormwater Management (SWM) Permits: Since the Fiberight facility will be permitted under the Solid Waste Rules, the facility will not be required to obtain either a SLODA or Stormwater Management Permit. However, if roadway or other infrastructure improvements are required (i.e. industrial park road) to service the facility, which exceed the non-revegetated or disturbed area thresholds in the SLODA or SWM rules, MEDEP may require one of the permits. This would likely be the case if the infrastructure required will be under another owner (i.e. industrial park) and will not be exclusive to the processing facility.

Natural Resource Protection Act (NRPA) Wetland Alterations Permit: The level of environmental permitting will be site specific. If the facility will be constructed entirely, or partially on a greenfield site, a wetlands investigation will be required to establish the presence of on-site wetlands, significant wildlife habitat and wetlands of special significance. As part of this process, a review of the presence of State identified threatened and endangered species, essential wildlife habitat and species of special significance should be completed through the Maine Department of Inland Fisheries and Wildlife, and the Maine Natural Areas Program.

Army Corps of Engineers Wetlands Permit: Wetlands permit requirements will be controlled by the site selected and the natural resources present. This process will include a review of endangered species identified by U.S. Fish and Wildlife Service.

Local Permit. A facility of this type and scale would require permitting by the host community. Likely this permitting would be done under the municipality's Site Plan Review Process, and would involve the local Planning Board.

# Technology Review of the Fiberight Process

Submitted to the Municipal Review Committee (MRC)

**Dr. Hemant Pendse**

**Michael Bilodeau**

**Amy Luce**

February 4, 2015

FBRI FOREST BIOPRODUCTS RESEARCH INSTITUTE

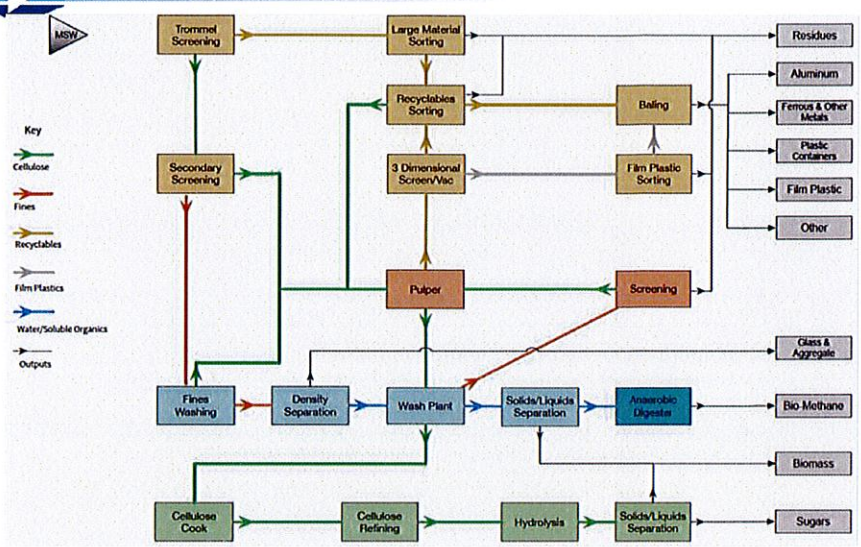
## Scope of Effort

- Limited to conversion of MSW to biofuels and other products
- Does not include financial analysis
- Key aspects of the Fiberight technology reviewed

1. Similarity of equipment and process to existing commercial processes.
2. Scaling of demonstrated technology to commercial scale.
3. Demonstrated conversion of MSW organics to commercial products.
4. Issues related to air or odor emissions, solid or liquid wastes.

MAINE

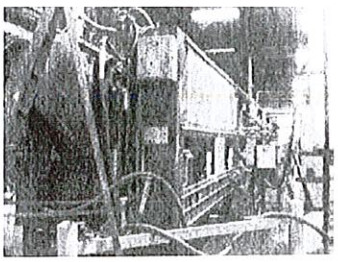
## Process Review




MAINE

## Front-End Separation System

- Initial step separates 'recovered recyclables' from land fill stream.
- Hot water pulping aids in separation of organic and recyclable fractions.
- Both Separation steps use standard MRF equipment.
- Organic fraction is washed separating biomass into
  - Soluble fraction which is fed to anaerobic digester
  - Insoluble, cellulose-rich fraction which is fed to hydrolysis reactor
  - Inorganic waste stream which is land filled.



MAINE

## Conversion of MSW Organics

- Evaluated following proposed MSW organic conversion technologies
- Soluble Organics
  - Wash water rich in soluble sugars converted to biogas via AD.
  - Methane-rich biogas upgraded to pipeline gas standards or CNG.
- Insoluble Organics
  - Washed, pre-treated cellulose solids enzymaticly hydrolyzed
  - Concentrated sugar solution sold as product, or
  - Fermented into biofuels or other biomaterials.
- Biofuels from separated-MSW feedstock quality for RIN credits

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MAINE

## Anaerobic Digestion

- A "liquid-only" anaerobic digestion (AD) system proposed.
- AD process produces
  - clean water - internally reused in wash system
  - generates minimal digestate
- Pilot operating experience with small commercial Voith AD unit
  - Voith R2S reactor - 8,000 gallon
  - Capacity of 1,320 lb COD/day
  - Feed limit of 500 ppm suspended solids
- Fiberight evaluating a Hydrothane AD system
  - Expanded Granular bed (EGB) AD systems.
  - Higher suspended solids feed limit - up to 2,500 ppm
  - To be deployed in Fiberight's Iowa plant

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## Enzymatic Hydrolysis

- Enzymatic hydrolysis proposed to produce fermentable sugars.
- Thermo-mechanical pretreatment of washed MSW-derived pulp press cake
  - pH adjustment
  - cooking at 260°F for 30 min in a pressurized vessel.
  - Followed by low consistency refining and dewatering
  - Produces clean and sterile MSW-derived pulp press cake.
- Very similar to Old Town plan for sugar production from Kraft pulp.
  - Fiberight efficiency - 40-50% vs. 90-95% for virgin pulp
  - Less efficient due to hornification of fibers
- Unhydrolyzed solids separated and dewatered to burn onsite
- No scale-up issues are anticipated for these operations.

## Options for MSW derived sugars

- Conversion of MSW derived sugars to ethanol
  - Fiberight and Novozymes have completed bench scale conversions.
  - C6 sugar conversion to ethanol is within industry standards.
- Ethanol from MSW derived sugars
  - Proposed for Fiberight's plant in Iowa
  - But not for Fiberight's plant in Maine.
- Concentrated simple sugar solution potential product for Maine plant.
- Alternative is supplemental biogas production via AD
  - Opportunity in Maine due to high natural gas prices in winter months
- Alternatives avoid capital investment associated with ethanol production.
- Potential Risks
  - Cellulosic sugars are an emerging market.
  - Transportation costs
  - Contamination during transport

MAINE

## Site infrastructure and permitting needs

- Mass and energy balance should be obtained and reviewed.
  - Identify on-site waste water treatment and solid waste disposal needs.
- Emerging markets in Maine for end products
  - Biogas produced from AD
  - Cellulosic sugars
  - Unhydrolyzed biomass
- Possibility of accepting pulp or paper mill sludge to supplement MSW
- Permitting process could take 6 months to one year.
  - Begin as soon as FEL 3 level completed
  - Proximity to Acadia National Park and Moosehorn Preserve could raise air emissions concerns.

Inquiry 2d

MAINE

## Technology Readiness and Project Implementation Considerations

- Scale up risk for proposed Fiberight technology is low.
  - Process equipment for converting MSW derived organics
    - Demonstrated at Fiberight's Lawrenceville, VA pilot plant
    - Sufficiently similar to pulp and paper industry deployment
- Strategic equipment suppliers
  - Vickers Seerdrum - continuous pulper
  - Milnor - two stage washing unit
  - Andritz - cooking and refining
  - Proquip – mixing
  - HydroThane - expanded granular bed reactors for the AD plant
  - Novozymes - enzyme and technical support
- Next steps for Maine project
  - Define the scope of the project
  - Review final products – markets and end users/customers.
  - Allocate resources required for planning, permitting and equipment purchase and installation

## Summary

- The scope was limited to biological and chemical conversion of MSW to biofuels and other products.
- Economics of the Fiberight operation are outside the scope and have not been evaluated.
- FBRI conducted a detailed study including a site visit to Fiberight's demonstration facility in Lawrenceville, VA.
- Subject matter experts were consulted for comparison to similar biofuel processes and to identify potential site location and permitting issues.

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## Summary (cont.)

- Fiberight's processing technology is sound and capable of converting MSW organics to a simple sugar solution and biogas.
- Fiberight's MSW-derived sugars have been converted to ethanol on a laboratory scale.
- Selection of final products will have a significant impact on project economics.
- Proposed equipment and processing steps are similar to those found in the pulp and paper and related process industries.

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MAINE

## Summary (cont.)

- No extraordinary issues are anticipated in scaling the Fiberight technology to commercial scale.
- Potential odor issues are primarily limited to the front end - trash storage and processing.
- Air emissions would be associated with combustion technology selected for residual biomass and post hydrolysis solids.
- Fiberight's experience in Iowa should prepare them in addressing winter operation issues.

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BANGOR DAILY NEWS (http://bangordailynews.com/)

# Trash group signs deal to send waste to Norridgewock landfill (http://bangordailynews.com/2015/07/30/news/bangor/trash-group-signs-deal-to-send-waste-to-norridgewock-landfill/)

Nok-Noi Ricker | BDN

Greg Lounder (right), executive director of the Municipal Review Committee Inc., announced Friday, March 28, 2014, that the group is requesting permission from the state to open a landfill and recycling facility in Greenbush or Argyle. The Municipal Review Committee's general council, Dan McKay, sits beside Lounder. The yellow on the map of Maine indicates the 187 communities that make up Municipal Review Committee and send solid waste to the Penobscot Energy Recovery Co. waste-to-energy plant in Orrington. *Buy Photo* (http://store.bangordailynews.com/Other/Week-of-July-27-2015/50875771_9ssTCr#4242496565_tSpQQNZ)

By Nok-Noi Ricker (http://bangordailynews.com/author/nok-noi-ricker/), BDN Staff
Posted July 30, 2015, at 7:45 p.m.

HAMPDEN, Maine — The group representing the trash-disposal interests of nearly 200 Maine towns has taken another step toward operating its own recycling and processing facility by signing a contract that will send leftover waste to a landfill in Norridgewock.

The Municipal Review Committee (http://www.google.com/url?q=http%3A%2F%2Fmrcmaine.org%2F&sa=D&sntz=1&usg=AFQjCNH28GPNs0m45ZNytsREJ1gmzAfs8w), which is working on a proposed $69 million facility in Hampden that will turn trash into biofuel and recycle other materials, approved a 10-year contract Wednesday with Waste Management of Houston to take the plant's residuals. Waste Management operates the Norridgewock landfill.

The signing came 10 months after the state denied MRC's request to operate its own landfill in Greenbush or Argyle to handle the proposed plant's residual materials. The landfill proposal caused an uproar from residents (http://www.google.com/url?q=http%3A%2F%2Fbangordailynews.com%2Fslideshow%2Fplan-to-build-landfill-in-argyle-or-greenbush-draws-fire-at-maine-dep-public-meeting%2F%3Fref%3DrelatedBox&sa=D&sntz=1&usg=AFQjCNHvUfu1iiW20GFeYrfothosUrZUXg&ref=inline) and members of the Penobscot Indian Nation. The Maine Department of Environmental Protection (http://www.google.com/url?q=http%3A%2F%2Fbangordailynews.com%2F2014%2F09%2F25%2Fnews%2Fpenobscot%2Flandfill-denial-a-step-backward-but-mrc-still-working-to-resolve-trash-problem-executive-director-says%2F&sa=D&sntz=1&usg=AFQjCNH-_j5XelawcEN443I-2usieQAPkg&ref=inline) said in its denial that there is sufficient existing disposal capacity in the state.

The MRC, which represents 187 Maine towns that currently send trash to the Penobscot Energy Recovery Co. in Orrington, found it could not send its residuals to Juniper Ridge Landfill in Old Town because PERC already sends its residuals there. The proposed MRC processing facility is competing with PERC for trash contracts with the towns beginning in 2018.

"We've managed to find another way," MRC Executive Director Greg Lounder said Thursday, the day after all nine members on the MRC board voted to sign the Waste Management contract. "We're very happy we were able to reach this agreement."

Waste Management has agreed to take the Hampden plant's expected 30,000 to 40,000 tons in annual residue at $47 a ton, Lounder said.

Jeff McGown, senior district manager for Waste Management, said members of the MRC board approached the company with the idea about six months ago.

In February, the MRC officially partnered with Maryland-based Fiberight LLC (http://www.google.com/url?q=http%3A%2F%2Ffiberight.com%2Fabout%2F&sa=D&sntz=1&usg=AFQjCNHdUrvRLAuc_Fp7bSOoD2p74G2D_w) to create a solid waste recycling and biofuels processing facility located in the "triangle" area between Ammo Industrial Park, Interstate 95 and Coldbrook Road.

At the Hampden plant, Fiberight's technology will change organic materials in trash into biofuels, called Trashanol, after the glass, metals, papers and plastics are recycled.

The MRC's leaders started looking for alternatives more than five years ago because they believe that PERC (http://www.google.com/url?q=http%3A%2F%2Fwww.percwte.com%2F&sa=D&sntz=1&usg=AFQjCNEgxEMorQMLODoVDwv4soa03ErNgQ), of which it is part owner, will not be profitable at the beginning of 2018 when lucrative agreements for the electric power it generates expire.

Lounder said after the recyclables are removed and the organics are turned into fuel, about 20 percent remains that needs to be landfilled, which means roughly 80 percent of what goes into the trash is reused or recycled under the MRC-Fiberight plan.

Waste Management has also agreed to provide disposal services beyond residuals, Lounder said.

If for some reason the plant is not operational by April 2018, when all the new not-yet-signed trash disposal contracts go into effect, Waste Management has agreed to take all the group's waste. The Norridgewock waste and recycling company also has agreed to be used as a backup, if crews end up fine tuning the new processor in Hampden.

"Sometimes it takes a while to get all the kinks out," Lounder said. "This will eliminate any service gaps."

The cost per ton would increase to $62 for the extra disposal services, McGown said.

Robert Knudsen, vice president of operations for PERC part-owner USA Energy, described the MRC's move "as part of the normal process of the project development," and added PERC already has the same contract in place for residuals with Juniper Ridge.

USA Energy plans to continue to operate the incineration plant (https://www.google.com/url?q=https%3A%2F%2Fbangordailynews.com%2F2015%2F07%2F02%2Fnews%2Fbangor%2Ftrash-to-energy-facilities-fight-to-dispose-of-maine-towns-waste%2F&sa=D&sntz=1&usg=AFQjCNH4YvYfMr_YWXhvERltPVhDedORJg&ref=inline) in Orrington and is offering communities a draft contract now.

USA Energy controls about 52.7 percent of the PERC plant, PERC Holdings owns 24.3 percent, and the other 23 percent is controlled by the original member towns and cities that became part of the Municipal Review Committee Inc. before 1998.

http://bangordailynews.com/2015/07/30/news/bangor/trash-group-signs-deal-to-send-waste-to-norridgewock-landfill/ (http://bangordailynews.com/2015/07/30/news/bangor/trash-group-signs-deal-to-send-waste-to-norridgewock-landfill/) printed on October 9, 2015