E = MC³ ©

Energy=Maine Chips³ ©

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Subject: Phytosanitized - Heat Treated Biomass - Wood Chip Densification

Attention: Industry Affiliates and CHP Procurement Professional

This document addresses wood chip production and handling issues regarding Phytosanitation (*heat-treatment*) and chip densification processes we developed and enhanced upon since exporting our first test-shipment of high-quality Kraft wood chips to Mercer International in Germany in September 2014. As research and development continued we shifted our primary focus to renewable energy - biomass markets – emerging exponentially throughout the EU-28.

While the Mercer test-shipment was successful with utilizing the Thomson Dryer Heating System we faced other challenges such as moisture content versus weight control, supply chain handling issues, cost containment of production, carbon footprint, and emissions reduction, wood chip structural integrity, then vessel loading and ocean freight shipping efficiencies.

As Phytosanitation (*heat-treatment*) is applied to wood chips, the resulting weight reduction posed meaningful handling, loading, and vessel stowage issues. However, as moisture content levels drop we realize increases in energy value. To perfect the calculus and better understand the dynamics of changes between those values related by a function of heat, we began the process now perfected here. From forest to furnace, we developed the most cost-efficient, lowest carbon-footprint process currently devised for high energy, densified wood chips from the US today.

Driven by extraordinary growth trends for biomass demand, throughout the EU, we concentrated on the combined heat and power (CHP) industry. Early innovation in this market focused on wood pellets as the world’s answer to renewable energy and sustainable, carbon-neutral supply. Our preference for markets was wood chips only. Since 2012 it became apparent that entering the pellet manufacturing arena would be cost-prohibitive for many and eventually lead to only a small number of successful, powerful, highly competitive, low desired-margin wood pellet suppliers in the US. There were, and still are, industry shake-outs where pellet manufacturers are contracting in size, looking at consolidation strategies, or diversifying. While the pellet manufacturing industry aggressively chased CHP facilities throughout the EU, they left open another lane that was entirely non traveled. That is the road we took.

We decided to serve only the wood chip, biomass market. We targeted CHP plants intending to either co-fire with wood chips or to exclusively rely on wood chips as their renewable and sustainable fiber source. Our second targeted market focused on wood pellet manufacturers in the US because their raw fiber needs are wood chips and with their export markets growing exponentially, they also rely upon quality wood chip supply sourcing.

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We correctly and timely predicted in 2014, that Phytosanitation of wood chips would become the approved method of preparing wood chips for allowable imports into the EU. Any use of chemical-based fumigation would be banned so fumigation was replaced by Phytosanitation. Also, correctly forecasted, there would arrive a time, that an environmentally based awakening about forest harvesting activities throughout the EU-28 would impose stringent controls over forest management and harvesting for biomass. We are there today. Those limitations have impacted US forest management and harvesting activities in every corner of the country. To serve the industry well, we eventually developed our designer wood chip, which we have trademarked as **E** = **MC^3**, which stands for **Energy** = **Maine Chips Cubed**.

Regardless of being in the middle of 17-million acres of forests, at the base of a dedicated rail line, terminating at our 17+ acre site, within 1,200 feet of a dock at a deepwater port, closest to anywhere in the EU from the US - and able to produce more than 300,000 MTPY of wood chips for export - none of that matters unless you can load them to a vessel and transport them in an effective, efficient, and cost-contained manner. This took us back to the calculus mentioned above. To solve for that we devised a wood chip densification process that puts our **E** = **MC^3**, on a vessel at a densification quotient exceeding wood pellets.

Densification of wood chips was the key to opening the market for export. We provide an overview of the process from raw fiber sourcing to vessel voyage. The approach we take is inclusive, but not limited to the following: 1.) perceived overcutting or intrusive harvesting of forests; 2.) procuring only from sustainably managed and appropriately certified forests; 3.) a rigorous focus on green-house gas (GHG) and CO_2 reduction levels; 4.) ensuring wood chip quality and exactness to specifications – materials aggregation and handling; 5.) meeting and exceeding EU import Phytosanitary regulations and mandates; 6.) densification for material handling and vessel loading efficiency; 7.) elimination or mitigation of costs related to chip pile handling affected by weather and climate exposure – and high costs of buildings associated with port storage; and 8.) ocean freight cost containment achieved through strategic alliances and solving density/stowage concerns.

Perceived Overcutting or Intrusive Harvesting:
We want to be recognized as industry leaders who practice sustainable forestry in a non-compromising manner so that our forests will be sustained by practicing ethical and sound land stewardship that assimilates reforestation, growing, nurturing and harvesting forests for useful merchantable products and enhancing ecosystem benefits such as conservation of our soil, air quality, and water condition. We hope to be so recognized in global circles within the wood and fiber industry. We do not wish to be in stories printed in such publications, however, as the Dog Wood Alliance, where their favorite target is Enviva.

An example of their reporting includes, “there are four Enviva facilities around the North Carolina – Virginia border with a total estimated annual capacity of 2.08 million tons, which

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comes to nearly 50,000 acres (20k ha) of southeastern forest cut down each year! That's a larger forested area than all of Washington, D.C." They continue with, "To meet current demand, [Enviva] will have to cut down 80,000 acres (32k ha) of southeastern forest in 2017, while actively managing nearly 9 million acres (3.6 million ha). By 2030, these figures jump to 280,000 acres (113k ha) of forest cut down annually, with more than 10.5 million acres (4.2 million ha) under active management."

You do not want to be included in this perception, which is also driven by the mere fact that to produce 2.08 million metric tonnes of industrial wood pellets, one needs to harvest and process about 4.8 million US tons of raw fiber annually. We can argue the numbers are not that drastic, however, the argument becomes the reality such as in Alinsky's Rules for Radicals mentions, "If you push a negative hard and deep enough it will break through into its counterside."

What we have proposed to the pellet industry all along is that we would produce an energy wood chip that would complement wood pellets in such a manner that our wood chips would reduce the impact on forests and produce an alternative added biomass fiber that would lower the overall cost of supply to the CHP facilities by blending both.

Sustainably Managed - Appropriately Certified Forests:
Maine contains an estimated 17.6 million acres of forest land and covers 89.1% of the land area in the State. Most of the forest land, 95.3 %, is classified as timberland, meaning that it exceeds a minimum level of productivity and is not legislatively reserved from timber harvesting. Forest land, in Maine holds an estimated 23.9 billion live trees ≥1 in d.b.h.

These trees have a total above ground biomass of 713.8 million tons and, looking at trees ≥5 in d.b.h., a total net volume of 27.3 billion ft^3. The ratio of net growth to removals is 1.4:1. Certificated Fiber is derived from a.) 1.55 M acres FSC; 2.) 2.83 M acres SFI; and c.) 3.26 M acres both FSC and SFI for a total of 7.64 M acres.

Sustainability Statistics
Considering all Four (4) Mega Forest Regions

Certifications

Major Landowners Harvest Acreage

Certifications	Acres	Owners
FSC	1,548,319	11
SFI	2,831,237	7
FSC & SFI	3,257,579	1
	7,637,135	**19**

Every landowner has cutting plans, sustainability plans and works with licensed, certified Forester to define annual cuts and to oversee all required to supply fiber from the land through licensed logging companies.

Logging Contractors and Trucking Firms

Total	**86**	
Within 50 mi	53	62%
Beyond 50 mi	33	38%

5,000,000	US Tons Available
4,508,500	Metric Tons Available

Green-House Gas (GHG) and CO_2 Reduction:
Addressing the essential components of GHG and CO_2 reduction is where the most progress was achieved in terms of decreasing both raw fiber "as-received" costs, and the carbon intensive transportation emissions burdens on the atmosphere. By having an aggregation yard at the base of the primary rail line that connects Searsport to Montreal and St. Johns New Brunswick CA, we could accumulate and then process inbound fiber by rail versus by traditional trucking. Extensive study and in-depth testing of actual rail moves revealed a raw fiber cost reduction over 26% and a GHG emissions reduction of roughly 86%.

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As an example of the change in reliance on trucks toward the rail, we consider that a truck and trailer will carry about 27 metric tonnes per load and a rail car can deliver about 75 metric tonnes per rail car – with a rail service towing 50 to 75 rail cars at a time – that adds up. The availability of fiber is also increased due to the regionally of rail sidings throughout Maine. When a logger can deliver three truck-loads of fiber to a rail siding in his backyard, he can increase his revenue almost threefold, and be home for dinner, whereas he may have only delivered one or maybe two, at the most, loads per very long day. Moving 300,000 metric tons by truck is 11,100 truck trips (each direction).

<u>Quality, Exactness to Specifications –Aggregation and Handling:</u>
The justification for locating a fiber-hub for aggregation and processing, on the port in Searsport, Maine is two-fold. The obvious is that it eliminates transport costs to bring processed materials to the port for vessel loading. We are already there thus, reducing once again the supply chain costs of exporting biomass wood chips from Maine. The most important consideration however is that by aggregating, sorting and processing, debarking, and chipping to exacting specifications is heavily controlled so a designer wood chip will not deviate from its species mix, chip sizing, and classification, moisture content, and or final export density. The risk of an accidental mixture of species, for instance, coming in on a truck, already pre-chipped or processed, is too high.

<u>Exceeding EU Import – Phytosanitary Regulations and Mandates:</u>
When exporting wood chips to any EU destination we have to first verify the species allowed to be imported into certain countries. We begin with a global search on a U.S. Government information system, the USDA-APHIS website that identifies all species allowable for import into countries.

Once into the system, we can further identify, through a Phytosanitary Export Database (PExD), any of the official requirements for importing fiber where a Phytosanitary Certificate (PC) is required along with an additional declaration stipulating, "Consignment complies with Article 10, 3, point 4 (c) of Commission Implementing Regulation (EU) 2019/2032" and "The wood or isolated bark has undergone an appropriate heat treatment to achieve a minimum temperature of 56 C for a minimum duration of 30 continuous minutes throughout the entire profile of the wood, and an HT mark is located on the wood or wrapping, which is to be accomplished with an SKU Label, on each densified bale of biomass exported. The entire chaoin of custody, together with its treatment process and delivery on board vessel is to be included within the verifiable data embedded in the SKU.

There is an acceptable range of moisture content and connectedness NCV and bulk density of the wood chips, which allows us to get the best economic results of ocean freight cost for sea transportation. Moisture in these cases has to be approximately 38-40%. However, the optimum MC to meet densification and NCV value is targeted at 30% MC. Any MC over 50% and below 30% can produce both physical and economic problems.

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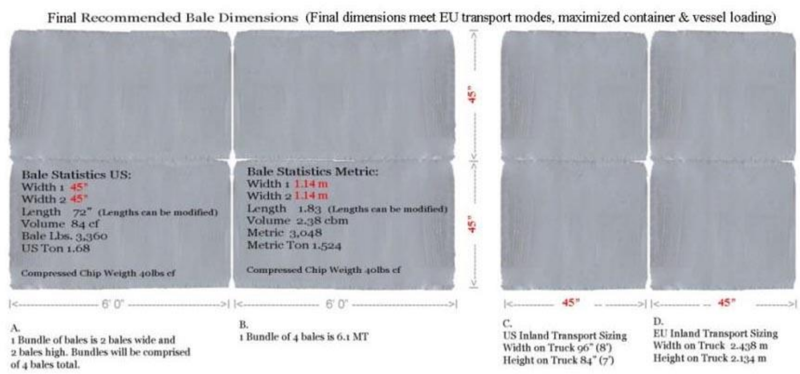
Reaching a desired MC with our Phyto System design criteria is substantially less cost-burdened than achieving traditional goals of dehydration, typically the desired outcome for production of wood pellets, where drying is implemented to reach 10% to 15% MC as a norm. Getting past the archetypical constructs of dehydration was not easy for manufacturers to grasp at first. Thinking as a lawyer would, we started with the "Call of the Question" or to put it in layman's terms, "What is the EU mandating?" – They are not demanding a wood hip to be 10% to 15% moisture content orientated. The mandate is to prove that we heated the wood chips to 56° C for 30 minutes to the core of the chip. That means if a wood chip is in the dryer at 45% fresh-cut MC and it gets to 56° C – and you can show (by third party inspection reporting) that the chip was held to that temperature (in a silo) for 30 minutes – the Phyto requirement is satisfied.

Going back to chip species, chip size, original MC in the dryer and duration; we can put a 40% to 45% MC chip in for a half-hour and drop to 30% to 35% MC at very low cost. If we wish to get a higher Gigajoule value we turn up the heat or extend the duration. However, extending the duration will reduce the throughput volume by a factor of that time.

Densification (Bale Sizing) for Material Handling and Vessel Loading Efficiency:
Bale Sizing:
Because we were looking at loading into vessel holds and shipping containers, we devised a bale size that would efficiently fill both – while being one size only so the baling system could retool its compaction chamber to meet the need. The traditional Apollo bale sizing, was 40" x 48" by variable lengths (height if you choose) that could range close to eight (8) foot. Our ideal bale dimensions are 45" x 45" x 72" or about 84.37 cubic feet. One important caveat is that the length/height of the bale, during compaction can be adjusted by stopping the process at a set height. Depending on the intended transport mode, the bale size could be modified to perfectly fit out a container or vessel hold. The integrity of the bale dimensions is extremely rigid and can be similarly compared to a solid block of wood.

Inside dimensions of a shipping container for a 20' box are roughly 92" x 92" by 19' 6" with (1,118 cubic foot capacity) versus 92" x 92" by 39' 6" for a 40' box with a 2,377 cubic foot capacity). The maximum cargo in a 40' box is roughly 58,000 pounds or 26 metric tonnes. The maximum cargo in a 20' box is roughly 62,000 pounds or 27 metric tonnes. While that does not automatically make sense, there is the issue that tare weight for a 40' is 8,377 pounds and a 20' box is 5,000 pounds. The difference in box weight alone is 1.67 us tons or roughly 1.5 metric tons.
Chip Densification:
We experimented with both deciduous and coniferous species of wood chips. We also test baled sawdust, mill shavings, bark mulch, and ground hog-fuel fiber. To meet the requirements for biomass production we obtained the following densification at an average 30% moisture content (MC) and with the bale sizes, we defined as best practice size to meet all vessel and container maximization of loading parameters. We used (45" x 45" x 72") or (3.75' x 3.75' x 6') and we

obtained 84 cubic feet. We achieved 3,360 US pounds or 1.68 US tons ~ 1.52 MT. Our final densified-chip weight for 40 pounds per cubic foot is shown here.



<u>Chip Sizing and Classification</u>
Wood chips are defined as the following: chipped woody biomass in the form of pieces with a defined particle size produced by mechanical treatment with sharp tools such as knives. Wood chips have a sub-rectangular shape with a typical length of 5 mm to 50 mm and a low thickness compared to other dimensions.

Example of raw fiber before densification and after. Solid as a brick.

<u>Mitigation of Costs Related To Chip Pile Handling - Weather and Climate Exposure –High Costs of Buildings Associated with Port Storage</u>:
To give an example of the size and scope of a wood chip pile of between 25,000and 30,000 metric tonnes, one would require a surface area of three to four acres of land and with a pile almost 30 feet tall. The cost of maintaining that pile, by bulldozing it upward, covering and uncovering the pile continuously for pile-up or climate issues is daunting. If that land is on a typical port and situated near a loading dock – the cost of land alone is considerable. The major risk to the fiber is both its rehydration and susceptibility to contamination from airborne

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elements. If the wood chips had been heat-treated and they were provided a PC, then that PC is good for 14 days – not sufficient time to satisfy all of the handling issues and then still be under the hatch to protect the validity of the PC.

Gone: Storage Domes and Chip Piles

Our baled/densified **E = MC^3** is firmly enveloped in an impenetrable SKU-marked wrapping that meets EU requirements. Bales do not require storage under coverings, roofing structures and do not require warehousing. Baled fiber will not rehydrate, does not degrade as with pellets during handling, there are no oxygen depletion problems or spontaneous combustion complications. The bales have an extended storage shelf-life, which can easily last a year. Neither on the origination of the shipping side nor upon arrival at the discharge quay, there is no need for warehousing.

Ocean Freight Cost Containment:

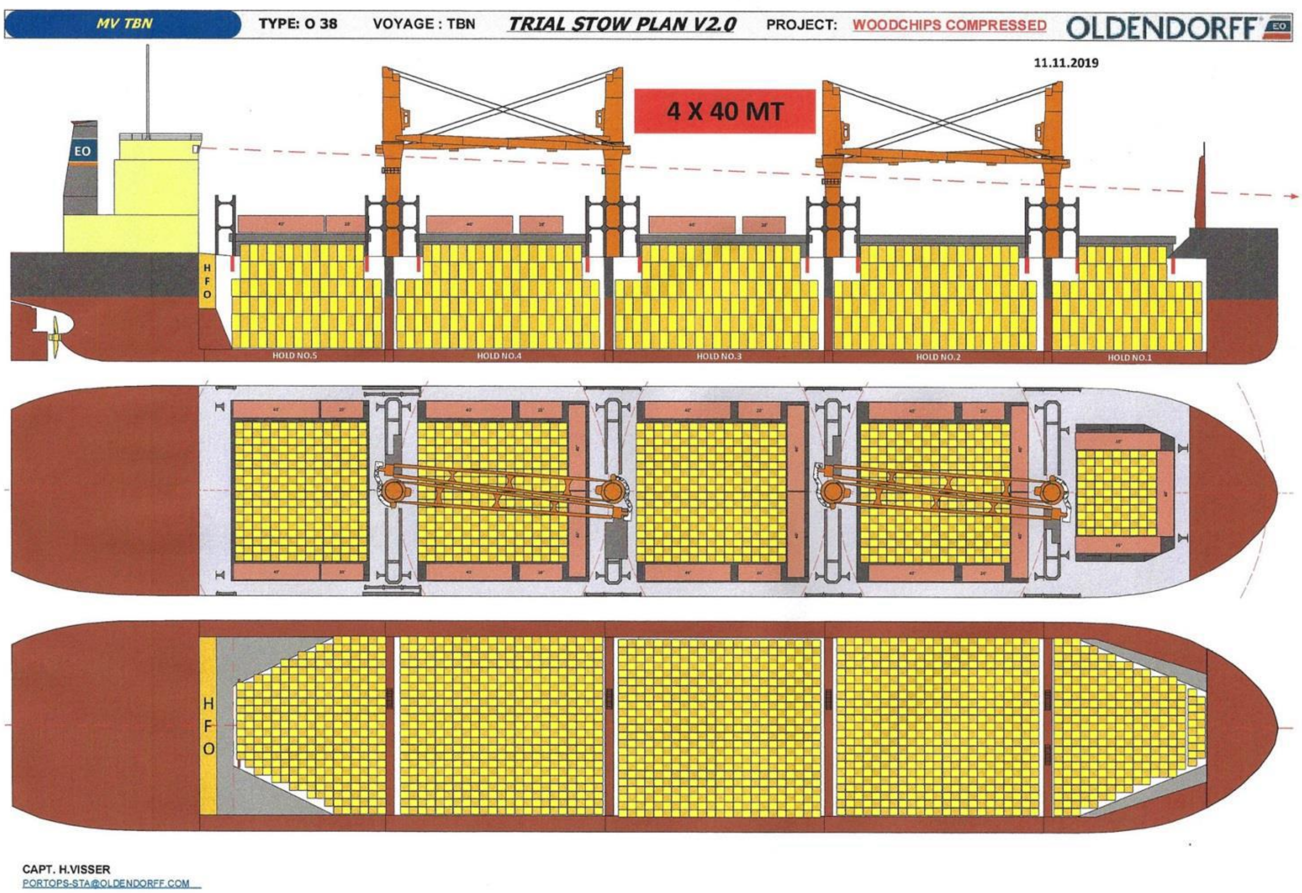
Loading bulk-loose wood chips to chip carries requires significant handling infrastructure that we simply do not have in Searsport. Even if we could utilize the existing Liebherr 550 Harbor Crane at the port, to load bulk wood chips, current port operation cannot offer a load rate above 6,000 MTPD – this is only about 65% of the load rate required to attract vessels for loose – bulk loading of wood chips. The international load rate must meet at least 9,000 MT per day for a four (4) day port call maximum.

The loose loaded bulk process, even if utilizing highly skilled loading professionals and proven trimming procedures such as in Belledune NB Canada, (*where they can load with Telestackers at 14 KMTPD*) we would still not be able to provide an economical stow value (*density*). Taking into consideration a vessel suitable to the Port of Searsport, we model an Oldendorff Handysize vessel with a cargo capacity of 38,000 DWT and has an approximate 10 meter (33ft) draught. The port of Searsport can easily handle this size vessel. If we use the 38,000 DWT, we stow bulk loaded wood chips on this vessel as follows: 1.) We use 90 cf per mt; 2.) 2.5 cubic meters per mt; and 3.) using an average of 1.5 million total cubic feet per Handysize vessel.

We can take 1,500,000 cf divide by 90 cf per MT and we get we can only load 16,667 MT under hatch. Let's use $750,000 for an approximated ocean voyage one way. That equates to $45.00

P/MT for ocean freight. Next, take the baled wood chips at 55 cf per MT and we can stow 27,275 MT under hatch. Take the same $750,000 ocean voyage budget and we are now at $27.50 per MT for ocean freight. We save roughly 40% on a per MT rate and we get an additional 60% more wood chips on the vessel. Finally, we look at the fact that the vessel can load above (2 bales high – strapped) and around the hatches (containerized), an additional 3,000 MT.

Therefore, on the Oldendorff Handysize vessel contemplated, we can load a total of 30,275 MT. Using the $750,000 rate we now have $24.75 per MT for ocean freight. That rate is below the typical cost to ship wood pellets.



<u>Financial Benefits from Acting Responsibly:</u>
As indicated above, the focus of our entire program is not to replace or displace wood pellets from the biomass area, but only to supplement it and or to provide a partial alternative to wood pellets in recognition to and avoidance of everything from perceived over-cutting and intrusive harvesting to a meaningful reduction in ocean freight transportation costs.

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Consider (*2021 forward pricing ARGUS: as an example only – from the US S.E. area to ARA*) a 2 million Gj supply contract for wood pellets CIF ARA, the cost would be roughly USD 185.00 or about $11.15 Gj or USD 22.3 million. Then, consider a 2 million Gj supply contract for densified energy fiber, **E = MC^3**. For **E = MC^3** CIF ARA, the cost is roughly USD 93.00 or about $7.15 Gj or USD 14.3 million. A $8.0 million savings. The above assumes 100% useage of either wood pellets or **E = MC^3**.

However, in the scenario proposed use is to be blended as supplemental. When considered as such, we can model a conservative 75% reliance on wood pellets and a 25% supplemental blend of **E = MC^3**. The balance changes to 1.5 million GJ of pellets at $185.00 and .5 million Gj or **E = MC^3** at $93.00. That equates to $16.725 million of pellets and $3.575 million in **E = M C^3** for a combined 2 million GJ and a total CIF of $20.3 million with a savings of about $2 million per year.

Cost Comparisons:

Industrial Wood Pellets vs. E = MC^3
Example of CIF from Southeastern USA to ARA
Considered as one or the other.

Gj Order	Pellet Gj	E = MC^3
2,000,000	17	13
$ per/Gj	$ 11.15	$ 7.15
Delivered $	**$ 22,300,000**	**$ 14,300,000**
Savings if move from pellets		**$ 8,000,000**

Example of CIF from Southeastern USA to ARA
Considered as a blened supply

Gj Order	Pellet Gj	E = MC^3
2,000,000	17	13
Blended	75%	25%
$ per/Gj	$ 11.15	$ 7.15
Delivered $	**$ 16,725,000**	**$ 3,575,000**
Blended Total	**$ 20,300,000**	
Pellets Only	$ 22,300,000	
Blended CIF	$ 20,300,000	
Annual Savings	**$ 2,000,000**	**8.97%**

Strategic Alliance and/or Joint Venture Collaboration:

The underlying goal is to deliver to a CHP facility, the highest quality fiber possible, within the governing specifications. Then to deliver them on a long-term sustainable supply agreement. The environmental, social, economic and globally responsible benefits are self-evident in any traditional transaction between Supplier – Buyer. However, we envisioned providing a better service by establishing a Strategic Alliance and/or Joint Venture Collaboration by and between the parties.

For instance, we worked with a UK regionally located CHP and proposed ways to reduce costs by working together to identify client-focused, cost-containment opportunities to benefit the buyer. While the exact details are not divulged herein, the general approach to the program is.

We categorized the most cost sensitive supply chain areas they are: 1.) initial procurement, aggregation, sort and natural drying process; 2.) heat-treatment – baling process 3.) inland transportation on the supply side; and 4.) ocean freight – handling from loading to offloading quayside.

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By establishing a JV between buyer and supplier, we considered the benefits to both parties by establishing a procurement fund to accumulate material up to roughly three months in advance. The ability to aggregate raw fiber, utilizing rapid payment not only reduces the raw fiber price, but also that fiber is laid out for meticulous sorting and classification, it also dries naturally and increases the Gj value – free of charge. This benefits both parties.

The entire processing of heat-treatment and densification is not addressed at this juncture howver, outside of this documents' considerations, a JV that includes buyer participation in the equipment/infrastructure to some degree could significantly impact the final per Gj price.

Inland transportation costs have been addressed in significant manner due to the location of the 17 acre dedicated site being situated both at the end of the rail and sitiuated adjacent to the deep water dock. This allows for port handling equipment to be used for FAS loading under the hook, where the vessel owner uses rigged vessel to rapidly load – then unload to quay. A marginal savings is realized here.

Finally, the most significant and often overlooked benefit; we model a JV transaction where the buyer makes direct payments to the vessel owner, which payment structure allows the supplier to move the ocean freight outside of its overhead. This cost reduction to the buyer is a direct result of the supplier not having to carry the vessel costs together with a mark-up in cost due to overhead. This arrangement provides a substantial savings to the buyer and opens another potential benefit to the buyer where a reciprocal back-haul to the origination port can be arranged (in this particular circumstance – we have arranged for that back haul potential).

Categories for Cost-Containment

Procurement	*Processing*	*Inland Transport*	*Ocean Freight*	*Total*	
34%	28%	3%	33%	98%	*Gj $*
$ 4,862,000	**$ 4,004,000**	**$ 429,000**	**$ 4,719,000**	**$ 14,300,000**	**$ 7.15**
Targeted Cost-Containment Savings					
8%		4%	9%		
$ 388,960		$ 17,160	$ 424,710	$ 830,830	$ 0.42
$ 4,473,040	**$ 4,004,000**	**$ 411,840**	**$ 4,294,290**	**$ 13,183,170**	**$ 6.59**

It is difficult to argue away a cost savings, but it is impossible to argue against the substantive benefits achieved by observing ethical and sound land stewardship and sustainable forest management practices. For additional information and or for confidential input for any planned project utilizing the above experiences, please do not hesitate to contact us by email or phone as provided for below.

Respectfully;

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