UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation Into the Technology Behind the Manufacturing of Sugar Cane and Wood Fiber Paper: Final Report

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Abstract

As the global human population continues to expand, so does the demand for resources and the consumption of paper products. In 1984, over 65% of the paper consumed worldwide was derived from wood pulp and only 25% of the paper consumption came from recycled waste paper (Kew, 2011). Sustainability has become a major part of how we interact with the environment and the availability of resources for future generations. To compensate for the increasing demand in paper and wood fibre pulp, sugar cane paper, which uses bagasse, has been introduced to the market. Bagasse is a by-product that remains after sugarcane and sorghum stalks have been used for their juice in the beverage industry. As of 2009, 5-10% of the paper produced worldwide has come from agricultural crops, such as bagasse. Currently, an increasing number of companies are considering converting their wood fibre paper factories into sugar cane paper factories. However, one of the issues that these companies face is the cost of transforming the factory into a sugar cane paper production facility. This report economically examines and compares the technologies used in manufacturing wood fibre paper and sugar cane paper. From thorough research, it was concluded that there is no significant cost of transitioning a wood fibre paper mill to produce sugarcane paper. In the manufacturing process, the same machine is used for making both wood fibre and sugar cane paper products. Thus, in regards to the manufacturing of sugar cane paper, the company does not need to think twice about transforming their factory since they would not need to purchase new equipment and sugar cane paper is a more sustainable option.

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1.0 Introduction

Sustainability has become a major part of our daily lives and with an ever-increasing demand in paper products, sugar cane paper is a valuable option for both the environment and paper manufacturing companies.

The purpose of this study is to analyze the technology used during the paper manufacturing process for both wood fibre and sugar cane paper. A thorough investigation will be conducted in order to determine the potential costs of transitioning from a wood fibre based to a sugar cane based paper production factory and costs to manufacture paper.

2.0 Pulp Material

This section explains and compares the two types of pulp used for making paper: sugar cane bagasse and wood fibre.

2.1 Sugarcane Pulp

Compared to wood pulp, sugarcane pulp is produced at a cheaper cost. Normally sugarcane is used to produce sugar by extracting juice from bagasse, and the bagasse would be burnt because they were of no further use. Therefore, after the development of sugarcane paper, sugarcane bagasse were being purchased at a cheaper. Other than the actual extracting phase, the bagasse will not need to be prepared in other ways before being treated chemically. Furthermore, due to the nature of the extraction phase and the formation of sugarcane bagasse, the sugarcane bagasse requires less bleaching chemical, and is able to achieve a similar bright and white quality that we see in normal wood fibre paper. However, the life cycle of sugarcane pulp is very short; once the sugarcane paper has been used, it cannot be recycled. Sugarcane paper and bagasse behaves much like garden waste and is 100% compostable. In general, sugarcane psprt will decompose in a home composting system in approximately 60 to 90 days. If the products were taken into a commercial composting facility, it will degrade faster.

2.2 Wood Pulp

Wood is normally of higher cost than sugarcane bagasse. However, due to economies of scale and the abundance of trees, wood fibre paper is manufactured and sold at a similar cost to sugarcane paper. Furthermore, wood is capable of being recycled and used to produce more paper, thus giving it a longer lifecycle than the highly biodegradable sugarcane bagasse. However, its long life cycle is offset by the cost. Depending on the amount of recycled wood fiber paper used in the process of making the pulp, the price could elevate significantly. When the paper is recycled, it is often filled with writings or drawings; hence, the first step is to get rid of the ink that covers the recycled paper. The chemical used to de-ink the recycled paper is expensive and will be used in large volumes. Furthermore, the entire recycling process is cumbersome. Recycling paper will only produce a fraction of the original amount of recycled paper into usable pulp for the manufacturing of new paper. Therefore, the pulp obtained from

recycled wood fiber will be more expensive than normal wood fiber pulp. In addition, due to the nature of wood fiber, to attain the bright white color often seen in paper the wood fiber must be bleached to cover its natural color, thus increasing its cost further. If 50% of the bagasse were made from recycled paper, its cost would be significantly higher than sugarcane pulp due to the amount of chemical used converting recycled paper into useable pulp and then bleached for papermaking.

3.0 Process Description of Pulp to Paper

In this section, the process of turning raw pulp into paper is outlined. Most production facilities have the same process to make paper; however, there can be minor differences in the process if the paper has a specialty niche of any kind. All different types of pulp can be made into paper using this same process, meaning both wood fibre and sugarcane paper are produced in the same way once the pulp has been obtained.

3.1 Pulp Bleaching and Preparation

Initially, both sugarcane and wood fibre pulp begin with a brown colour. To obtain white coloured paper, the pulp must be whitened using a chemical bleaching process. The pulp can be bleached with chlorine, oxygen or hydrogen peroxide. The pulp can even go through multiple bleaching processes (Fig.1) with different compounds and washes between each bleaching session.

Figure 1: Unbleached to bleached pulp with multiple stages (All-biz Ltd., 2013)

Rotating cutters used to refine the pulp into a thinner and more even consistency. Once again, more chemicals are added to the pulp such as fillers and dyes. The purpose of these additives is to make the paper appear brighter and more opaque. The fillers aid in making the pulp more malleable. To homogenize the pulp, approximately 100 kilograms of water is added for each kilogram of paper produced.

3.2 Sheet Formation and Moisture Drainage

After the pulp is processed, it is then suspended on a wired platform and uniformly distributed across the surface area. The fibres then form a layer on the wired platform as the water drains to the bottom. The pulp ratio across the surface is consistent as the water drains because the

fibres move into place corresponding to the ratio of the thickness and area of the platform. The drained water is also later collected for reuse.

The layer of pulp is then mechanically compressed by a Shoe Press, which further dries the pulp and evenly proportions the sheet. The remaining moisture in the sheet is removed using an evaporation process.

3.3 Surface Treatment of Sheets

A film press is an integrated part of the papermaking machine (Fig. 2). In this part, starch is added to the sheet to strengthen the paper. Simultaneously, the sheet is fed through a soft pair of rubber rollers. This controls the consistency and thickness of the sheets. The film press runs at high speeds and can be set to different consistency modes.

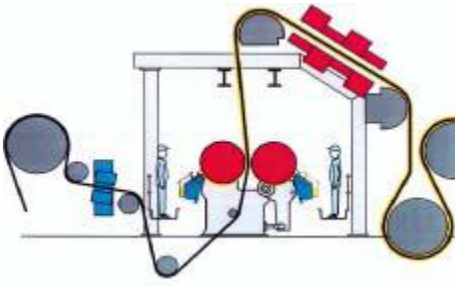

Figure 2: Film Press

3.4 Rolling

The long sheets are then rolled into large columns of paper, which are fed in through film press. Then the sheets can be cut to desired dimensions using rather a cross cutting machine (Fig. 3) or a Guillotine type cutter. The cross cutter is the most common way of cutting the paper but the Guillotine is used for cutting smaller dimensions. Modern cross cutters run an automated quality check and remove any sheets that are below the standard. Before the rolling process, there is an optional stage called coating. Some manufacturers choose to coat their paper for durability and an aesthetic shine.

Figure 3: Cross Cutting machine

To conclude, the following steps outline the process of making pulp into paper:

1. The pulp is bleached with numerous chemical baths
2. It is then refined using cutters for thinning and consistency
3. Filler and additives mixed in
4. Homogenized with water
5. Water is drained using wired plat forms
6. Sheets are mechanically compressed
7. Further drying and evaporation takes place
8. Fed into film press for consistency and thickness
9. Sheets fed into column rolls
10. Sections are then fed into cross cutting machine (or Guillotine)

Overall, this technology is relatively simple and straightforward. For centuries, the papermaking process has been used without significant variation. Since a basic papermaking machine can be fed with any type of pulp, it is evident that the modern papermaking machine is very versatile and will continue to be used for years to come.

4.0 Maintenance and Repair

For both wood and sugarcane fibre manufacturing, paper mills worldwide continually strategize to lower manufacturing costs and improve operating efficiency. The primary target of this streamlining is often in the category of maintenance expenditure, which represents one of the most costly aspects of mill operations, with a 56 percent majority of paper mills reporting maintenance budgets exceeding $5 million (US dollars) per year (Kahn, Bevis, Hayes, & Roland, 2002, p. 36).

4.1 Operator Performed Maintenance

The largest components of maintenance consist of operator-performed maintenance, repair work, and mechanical programs and practices. The first line of defense for avoiding reactive maintenance is the operator; if properly trained and experienced, operators can identify improper machine functioning and perform minor, routine adjustments which mitigates larger system failures and postpones the need for major maintenance efforts. These include cleaning, oiling, tightening, and inspection, which are mandatory practice and—although not particularly costly—are performed at frequent intervals (Gulati, 2000, p. 52). The largest fraction of maintenance involves repair of the mechanical equipment used in the mills. The primary need for repair is caused by simple mechanical wear of the equipment, as is common in any manufacturing process featuring mass production at industrial quantities. Due to the chemicals used in the pulping, conditioning, and bleaching of fibres, the corrosion and chemical erosion of machinery is also a common problem affecting paper mill equipment. As such, the damage inflicted by these means represents a significant source of financial burden to paper mills. Additional needs for repair work are created by vibration and impact strain, which contribute to the speed at which machines wear out, as well as routine secondary maintenance that arises out of normal use and operation (Gulati, 2000, p. 52). In order to avoid equipment failure or malfunction, and possible operator hazards, mills must invest in specific mechanical maintenance programs and practices. Among other things, these expenditures support aspects of mill operation such as vibration analysis, noise inspections, lube oil analysis, and alignment checks. Because these programs require specialized knowledge and equipment, their implementation is often very costly to mills, and due to their often time-consuming nature, are

not considered high-value practices despite their utility. In correspondence with the problems of corrosion and vibration, programs such as lubricating the machinery, vibration analysis, and wear analysis, and walk-down inspections are of great value to mills. Other activities such as temperature inspections and alignment checks are not given as high a priority (Kahn, Bevis, Hayes, & Roland, 2002, p. 37).

4.2 Labour Expenditures

As expected, labor expenditures also represent a significant portion of maintenance costs. Although maintenance does not constitute the majority of employment within paper mills, its contributing percentage to the mills' total employment is not negligible, with reported figures showing an average of about 20 percent with resulting labor expenditures in this area often representing between 30 and 40 percent of total maintenance budgets (Kahn, Bevis, Hayes, & Roland, 2002, p. 37). In addition to the salaries and assorted benefits earned by mill operators, concern for personnel safety also motivates more extensive inspections and rigorous emissions standards, which contributes to maintenance costs. The health risks and carcinogenic effects of the chemicals used in pulping, as well as the fumes and emissions generated throughout the manufacturing process, pose well-documented safety concerns. As a result, expensive precautions can be taken to reduce these risks, most of which fall under the maintenance category of mill expenses (Gulati, 2000, p. 54).

4.3 Preventative Maintenance

In an attempt to reduce the costs associated with repair maintenance, the emerging trend in the paper industry is toward preventative and predictive maintenance, which is quickly becoming recognized as best-practice in paper mills worldwide (Kahn et al, 2002, p. 39). Advances in sensor technology, and increasing availability of cost-effective measuring and diagnostic equipment, is rapidly promoting preventative studies as sources of highly practical expenditure. Providing this trend continues, paper mills will be able to reduce their overall maintenance costs in pursuit of cleaner, more efficient, and more sustainable pulping practices (Gulati, 2000, p. 51).

5.0 Economics of a Paper Mill

5.1 Initial Capital Costs

Building a new paper mill cost tens to hundreds of millions of dollars. A mill that can produce 1000 tons of paper per day costs around $300 million to replace (Montgomery & Chaffin, 1982). Each Fourdrinier machine in the paper mill cost millions of dollars. The cost of the machine is dependent on many factors including the speed of the machine as well as the cost of the supporting machinery. Many mills have multiple machines that run in parallel.

Each mill requires a large building to house several large Fourdrinier machines. Each Fourdrinier machine can be up to 500 feet in length and 33 feet wide (Penicuik Community Development Trust, 2013)

5.2 Operating Costs

5.2.1 Energy Usage

Energy usage of a paper mill accounts for approximately 25% of the cost of producing paper. Electricity and natural gas are the two main sources of energy used by paper mills. Electricity is used to power the paper mill as well as the machinery used for manufacturing paper. Natural gas used to heat water into steam for use in the production of paper. As Figure 4 shows, increasing the capacity of paper production increases the total amount of energy used. However higher capacity paper mills use on average less energy per ton of paper produced.

Table V

Capital Cost Structure of Non-Integrated Paper Mills
(second-hand paper machine)

million US$ 1/

	Capacity tons per day:	50	100	150
1.	Land and buildings including housing for essential staff	2.0	3.0	4.0
2.	Plant and machinery, of which:	5.0	8.0	10.0
	(a) Paper mill machinery including renovation and reconditioning	2.0	3.5	4.5
	(b) Utilities - water, steam, power, etc.	3.0	4.5	5.5
3.	Freight, erection and start-up expenses	2.0	3.2	4.0
4.	Engineering services	0.5	1.0	1.0
5.	Contingencies	0.5	0.8	1.0
	Total	10	16	20

1/ The cost does not include interest on capital, company formation and allied expenses, margin money for working capital, customs duty and other local taxes, etc.

Figure 4: Breakdown of Operating Cost in Paper Mills (Food and Agriculture Organization of the United Nations, 1983)

The 30% post-consumer recycled Boise Aspen Paper that Grand&Toy sells to UBC is produced by three paper mills, each capable of producing thousands of tons of paper per day. Boise Cascade's Wallula Washington paper mill is capable of producing 1600 tons of paper products are produced each day. The energy usage consists of 70% natural gas, 28% electricity and 2% residual fuel oil for manufacturing paper (Essay Info, 2013). In 2005, the total cost of energy to run the mill set Boise Cascade back $40 million. The mill consumed:

- 1.94 million MMBtu of natural gas at a cost of $16.6 million
- 444,000 MWHr of electricity at a cost of $17.3 million
- 1.7 million MMBtu of hog fuel at a cost of $4.3 million
- 171000 million MMBtu of reclaimed oil at a cost of $1.1 million.

Energy Source	2005 Consumption (MMBtu)	Current Unit Cost ($/MMBtu)	Estimated Total Cost ($)
Natural gas	1,940,019	8.57	16,625,966
Electricity	1,518,501	11.42	17,347,304
Hog fuel	1,734,480	2.50	4,336,199
Reclaimed oil	171,424	6.50	1,114,255
Total	5,364,424		39,423,723

Figure 5: Wallula Washington Paper Mill Energy Consumption (Tobin, 2005)

5.2.2 Maintenance Cost

Maintenance cost is a significant in the manufacturing process of pulp to paper. The Fourdrinier machines are complex and require regular maintenance. An hour of downtime when the machine breaks down or taken down for scheduled maintenance could result in a loss of as much as $14,000 ((WESCO Distribution Canada LP., 2012). Each time the machine is taken down for maintenance, the company loses tens of thousands of dollars in lost revenue and the cost of replacement parts.

In 2004, the Washington plant had several breakdowns of the lime kiln, which resulted in unscheduled maintenance costs of $87,000. Each time the limekiln broke down it would result in close to ten hours of loss production time for maintenance with a cost of approximately $35,000 each time.

In 2012, Boise Cascade paper lost a total 36,000 tons of paper production due to downtime in all three of the paper mills they operate. 17,000 tons was lost due to market-related downtime and 19,000 tons were for planned annual maintenance (Yahoo! Finance, 2013).

6.0 Conclusion

After conducting much research, we realized that the process of converting pulp into paper is the same due to the similar machinery used; hence, the nature of using wood fiber pulp or sugarcane pulp makes no difference. To further our findings, we contacted Mr. Mike Nilan of TreeZero Paper with the help of our stakeholder, Paula Goldspink. Over the phone, Mr. Nilan confirmed our findings by informing us the machines used in making paper is the same for producing either wood fiber paper or sugarcane paper. In addition he mentioned that the price difference between the two pulp sources arise from the process before the actually making paper, due to the chemicals used in recycling wood fiber, pulp made from 100% recycled wood fiber will be many times the price of pulp made from sugarcane.

References

All-biz Ltd. (2013). *Allbiz*. Retrieved from http://www.in.all.biz

Carter, C. (2000). Alternative Paper is No Joke. *The British printer*, 2-3.

Chandra, M. (1998, August). *Use of Nonwood Plant Fibers for Pulp and Paper Industry in Asia: Potential in China.* Retrieved from VirginiaTech: http://scholar.lib.vt.edu/theses/available/etd-91598-85139/unrestricted/Report.pdf

Essay Info. (2013, April 1). *Boise Cascade Corporation: An Analysis*. Retrieved from Essay Writing Center: http://essayinfo.com/sample/essay/664/

European Paper & Packaging Industries. (2013). *Making Paper*. Retrieved from European Paper & Packaging Industries: http://www.paperonline.org/paper-making/paper-production/papermaking

Food and Agriculture Organization of the United Nations. (1983). *Establishing Pulp and Paper Mills.* Rome: United Nations.

Garg, M. (2000). Comparison of printability of hardwood and bagasse papers with softwood papers. *IPPTA: Quarterly Journal of Indian Pulp and Paper Technical Association*, 7-13.

Gulati, R. (2000). Maintenance benchmarking: Best practices and survey results. *MARCON 2000 Maintenance and Reliability Conference Proceedings* (pp. 50-55.). Knoxville, Tennessee: University of Tennessee.

Hassan, E. A. (2010). Improving Bagasse Pulp Paper Sheet Properties with Microfibrillated Cellulose Isolated From Xylanase-Treated Bagasse. *Wood and Fiber Science*, 76-82.

Hurter, R. W. (2007, May 4). *Developments in pulp and paper manufactuing from sugarcane bagasse.* Retrieved from Hunter Consult: http://www.hurterconsult.com/HTMLobj-1213/QUT_Bagasse_Fibre_Procseeing_Overview.pdf

Kahn, J., Bevis, M., Hayes, M., & Roland, O. (2002). Benchmarking Maintenance Practices at North American Paper Mills. *Technical Association of the Pulp and Paper Industry*, 36-40.

Kew. (2011, December 12). *Paper.* Retrieved from Plant Scientists Investigate: http://www.plantscafe.net/media/files/enar03_Paper.pdf

Kulkarni, D. (1996). *Cane Sugar Manufacture in India.* Retrieved from The Sugar Technologists' Association of India: http://www.sugarresearch.library.qut.edu.au/108/1/Cane_Sugar_Manufacture_in_India.pdf

Lehoux, N., Marier, P., D'Armours, S., Ouellet, D., & Beailieu, J. (2012, July). *The Value Creation Network of Canadian Wood Fibre.* Retrieved from Cirrelt: https://www.cirrelt.ca/DocumentsTravail/CIRRELT-2012-34.pdf

Ltd, K. &. (2009). Paper mills seek bagasse availability. *The Hindu*, 1270.

Montgomery, A. A., & Chaffin, R. L. (1982, February 26). *Georgia Forest Research Paper.* Retrieved from Georgia Forestry Commision: http://www.gfc.state.ga.us/resources/publications/research-papers/GFRP26.pdf

Nickel-Kailink, G. (2010, April 28). *TreeFrog "Treeless" Paper – And WHERE Does it Come From?* Retrieved from WhatTheyThink Blogs: http://blogs.whattheythink.com/going-green/2010/04/treefrog-treeless-paper-and-where-does-it-come-from/

Notokoesoemo, O. (1986). Experience in Establishing and Operating a New Bagasse Mill. *Pulping Conference, Proceedings of the Technical Association of the Pulp and Paper Industry*, 141-151.

OCED. (2010, October 27). *OCED Global Forum on Environment.* Retrieved from OCED: http://www.oecd.org/env/waste/46102448.pdf

Ochre Media . (2013). *Innovation of Bagasse in Pulp & Paper Industry*. Retrieved from Pulpandpaer-Technology.com: http://www.pulpandpaper-technology.com/knowledgebank/articles/bagasse_innovation.html

Oltmans, J. (1936). *United States of America Patent No. 2,105,052.*

Paper Production. (2013, April 4). Retrieved from Lana: http://www.lanapapier.fr/en/company/paper-production/

Penicuik Community Development Trust. (2013, April 1). *The Fourdrinier*. Retrieved from Penicuik Community Development Trust: http://www.penicuikcdt.org.uk/papermaking/fourdrinier

PR Newswire. (2013, April 4). *TreeZero(TM) Introduces Innovative Tree-Free Copy Paper - TreeFrog(TM)*. Retrieved from PR Newswire: http://www.prnewswire.com/news-releases/treezerotm-introduces-innovative-tree-free-copy-paper---treefrogtm-91804189.html

Rainey, T. J. (2009). *A study into the permeability and compressibility of Australian bagasse pulp.* Retrieved from Queensland University of Technology: http://eprints.qut.edu.au/30394/

Tobin, D. (2005). *ESA-083 Final Public Report, Boise Wallula.* Wallula: Boise Cascade LLC.

U.S. International Trade Commission. (2002). *Industry Waste & Trade Summary: Wood Pulp and Waste Paper.* Washington, DC: U.S. International Trade Commission. Retrieved from http://www.usitc.gov/publications/332/pub3490.pdf

Vincent Corporation. (2008, February 21). *Bagasse Paper Mill*. Retrieved from Vincent Corportation: http://www.vincentcorp.com/content/bagasse-paper-mill

WESCO Distribution Canada LP. (2012, November 8). *WESCO delivers for the Wood Products Industry*. Retrieved from Wesco: http://www.wesco.ca/success_wood.htm

Wilson, S. (2010, April 22). *TreeZERO offers treeless paper*. Retrieved from Blorge: http://green.blorge.com/2010/04/treezero-offers-treeless-paper/

Yahoo! Finance. (2013, February 26). *Form 10-K for BOISE INC.* Retrieved from Yahoo! Finance: http://biz.yahoo.com/e/130226/bz10-k.html