The Fiber Cycle Technical Document

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Fiber Cycle Technical Document

Introduction

The companies participating in the Corporate Forum on Paper and the Environment asked Metafore to examine how the paper fiber cycle operates in Canada and the United States. The Corporate Forum was created as a result of a mandate member companies gave the Forest Products Association of Canada (FPAC) to facilitate a dialogue with North American based corporate buyers of pulp and paper on environmental issues. Metafore has been retained to convene and mange the Forum on behalf of FPAC.

Purpose

This document is a technical source that provides insight into the data sources and calculations employed as part of the research into the fiber cycle. The fiber cycle is defined as the interaction of fresh and recycled fiber in maintaining the production of paper. Understanding how this cycle works offers key insight to several questions. These include why fresh fiber must always be introduced into the system, how much recovered paper is used and how it is being used to make new paper grades.

It is not a stand alone report, but instead illustrates how different findings are technically derived. The related documents, which provide a detailed description of the fiber cycle, are an interactive power point and a frequently asked questions document. This report was subject to an external review process. Refer to the Annex, to learn more about the review process.

Addressing Key Fiber Cycle Questions

Metafore was asked to address several questions on the fiber cycle and provide answers that can be broadly communicated in a simple format. Those key questions are:

1. What is the longevity of a fiber cycle that relies only on recovered paper inputs?
2. How much fresh fiber is required to maintain the fiber cycle?

3. What is the material balance effect of shifting recovered paper supplies to a particular grade while overall market supply remains unchanged?

The Scenarios

There is an interest in not only understanding how the fiber cycle currently operates, but what would be the implications of a substantial shift in recycled and fresh fiber flows. Exploring these shifts offers insight into the effects on the longevity of the fiber cycle and the fresh fiber input required to maintain the cycle. The key variable that determines the mix of fresh and recycled fiber is the recovered paper utilization rate. The utilization rate indicates how much recovered paper, expressed as a percentage of total production, that is used by mills in Canada and the United States, that are manufacturing recycled pulp and paper. It is important to note that there are technical and economical constraints utilizing recovered paper when it comes to making certain new grades of paper.

Therefore, this analysis examines the distinct fiber cycle cases for four grades of paper: newsprint; printing and writing; tissue; and containerboard. There are two scenarios explored for each of the four grades.

1. **The current utilization rate in Canada and the United States—** approximately 50 percent of paper consumed in Canada and the United States is recovered, but the baseline utilization rate for each grade is estimated accounting for performance characteristics that dictate where recovered paper grades go, exports, and alternative uses such as insulation or animal bedding. Note that the volume of recovered paper utilized for the entire paper system is 35 percent of total production.[1]

2. **The maximum utilization rate—**this figure is determined for four major paper grades (newsprint, printing and writing, tissue and

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[1] Own calculations using FAOSTAT, 2005, Forestry Data, http://apps.fao.org/faostat/collections?version=ext&hasbulk=0&subset=forestry, accessed February 2005. Pulp and Paper Products Council, 2005, Canadian Pulp and Paper Industry Key Statistics 2004. Montreal, Canada. American Forest and Paper Association, 2004, Statistics of Paper, Paperboard and Wood Pulp. Washington, DC.

containerboard). The linear extrapolation method is used for estimating the maximum utilization rate by grade. A profile is first developed to determine how much of each grade is recovered, how much is used to make all grades of paper, how much is exported and how much is discarded. The maximum utilization rate is determined by assuming the flows of a type of recovered paper would not be unchanged if all discarded tonnage is recovered.

Determining the Longevity of the Fiber Cycle

The analysis requires mapping out not just what type of paper is recovered, but also where it goes. In most cases, recovered paper is used in making more than one grade. In some cases certain types of recycled paper cannot be used to make new grades.[2]

Finding such detailed data is difficult given that recovered paper grades can be made up of several different types of discarded grades. An additional challenge is that differing levels of information exist for Canada and for the United States. Nevertheless, there are data sources for both countries that offer insight into the make up of recovered paper consumption and how different types of recovered paper are utilized.[3]

To overcome data gaps, such as the make up of different recovered paper traded between the two countries, the linear extrapolation approach is used. The linear extrapolation approach involves a determination of fiber flows by grade based on the share of recovered fiber used by each grade. It is assumed that the make up of trade flows between Canada and the United States reflects the composition of recovered paper types that are utilized by mills in both countries.

Attaining the maximum rate is not possible across the system, since a portion of the recovered paper goes towards single use grades that cannot be recovered and reused. The estimated maximum utilization rates are calculated by determining how fiber that would otherwise be

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[2] Examples include recovered newspapers, which are used in not only making new newspapers, but also tissues and, while recovered containerboard is not used for making new magazines due to technical constraints.

[3] 3 American Forest & Paper Association, 2005. Recovered Paper Statistical Highlights 2004. American Forest & Paper Association, Washington DC. Pulp and Paper Products Council, 2005. Recyclable Paper Statistics for All Paper and Board Producers. Pulp and Paper Products Council, Montreal, PQ.

disposed of would flow to a specific grade. Therefore, it may be possible in that the feasible maximum utilization rates differ from this analysis. Experience in other countries suggest that maximum utilization rates could be higher for newsprint and corrugated containers, while recent technological developments and customer demands suggest a 100 percent utilization rate is not possible for the entire tissue grade. However, determining plausible maximum utilization rates would require drawing on an extensive number of technical and economic analyses and would still be likely to some debate. For these reasons, the linear extrapolation approach is used, as the intent is to illustrate that even with significant increases in recovery, fresh fiber would still need to be introduced into the fiber cycle to maintain paper production and use

Table 1 presents the information necessary to estimate the longevity of the fiber cycle for specific paper grades under the current recovered paper utilization rate and the maximum utilization rate for each grade.

Table 1- Paper Grade Variables

Variables	Newsprint	Printing & Writing	Container-board	Tissue
Consumption (tons)	13,392,015	32,054,053	33,667,669	7,932,259
Base Utilization Rate of Recovered Paper	28%	7%	43%	47%
Maximum Utilization Rate of Recovered Paper	44%	14%	66%	100%
Yield Factor[4]	85%	70%	88%	75%
Nonfiber Input Factor[5]	1.004	1.166	1.019	1.001

4 Based on own calculations and personal communications with David Church, Director of Transport and Recycling, Forest Products Association of Canada, February 7 and 8, 2005; Pete Grogan, Business Development Manager, Weyerhaeuser, February 14, 2005 and Inger Eriksson, Development Manager, Svenska Cellulosa Aktiebolaget, May 30, 2005.

Consider the example for newsprint to illustrate the equations used to determine the longevity of a fiber cycle that relies on solely recovered paper inputs are:

(1) $TPO = \sum PO_i$ where:

- TPO = total cumulative paper output from using recovered fiber;
- PO_i = paper output in each cycle; and
- i = the number of times fiber is recycled, which is assumed to be six times.[6]

The amount of paper output for each successive pass through the cycle is calculated as follows:

(2) $PO_i = PO_{i-1} * UR * YR^{i-1} * NF_{input}$ where:

- UR = recovered paper utilization rate;
- YR = yield rate for each successive reuse of fiber; and
- NF_{input} = a factor for estimating the portion of nonfiber inputs in paper products. This factor is 1.004, which implies that nonfiber inputs add another 0.4 percent to the weight of paper products.

As noted in Table 1, yield losses range from using recovered fiber to make newsprint are 15 percent. However, this figure is based on the practical experience of blending fibers that have been recycled once or twice, while examining this scenario requires mapping out how recovered fiber yields would decline if they are recycled and reused six times. Since this is uncharted territory, a conservative declining yield rate factor is used based on the number of times the paper has been recycled (see Table 2). For example, the yield rate for a piece of fiber that has been recycled three times is calculated as follows:

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5 Own calculations based on email communication with Tom Friberg, Director of research and development, Weyerhaeuser, February 22, 2006 and Canadian Pulp and Paper Association, 1993. Fibre Furnish Survey 1992. Department of Economics and Statistics, Canadian Pulp and Paper Association, Montreal, PQ.

6 Counting the original use, fiber is assumed to be used a total of seven times before it is too degraded to be used again for making a new paper product. To learn more on the limits to recycling paper see: TAPPI, http://www.tappi.org/paperu/all_about_paper/faq.htm. However, while technical properties suggest fiber can be recycled up to seven times, the number times it is actually reused is a function of the recovery rate. Paperloop offers additional insight into the relation between recovery rates and number actual uses of a piece of paper: http://www.paperloop.com/toolkit/paperhelp/9_7.shtml

- YR^3 = 85 percent * 85 percent * 85 percent = 61 percent.

Table 2- Recoverable Fiber Yield Factors

Times Recycled	Yield Factor	Times Recycled	Yield Factor
1	85 percent	4	52 percent
2	72 percent	5	44 percent
3	61 percent	6	38 percent

To determine longevity in terms of months the following equation is used:

(3) $L = (TPO/CONS_{2003}) * 12$ where:

- L = the longevity of the fiber cycle in months; and
- $CONS_{2003}$= the amount of newsprint consumed in 2003 in Canada and the United States, which is approximately 13.39 million tons.[7]

Note that annual consumption is being used to illustrate how the fiber cycle would function if we no longer used fresh fiber as an input. This assumes there would be a year's worth of paper consumption at our disposal. However, mills typically have anywhere between two to four weeks of fiber inventory at their disposal. Therefore, in actuality eliminating the fresh fiber input would result in a fiber cycle that would not function in a matter of days.

The following example demonstrates the outcome of these equations from using only recovered paper as a fiber input for the current utilization rate of recovered paper for making newsprint, which is 28 percent.

(1) TPO = 3,977,290 tons = 3,200,049+647,710+111,071+16,237+2,008+215

(2) PO_1 = 3,200,049 tons = 13,392,015* 0.28 * 0.85 * 1.004

PO_2 = 647,710 tons = 3,200,049 * 0.28 * 0.72 * 1.004

PO_3 = 111,071 tons = 647,710* 0.28 * 0.61 * 1.004

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[7] FAOSTAT, 2005, Forestry Data, accessed February 2005.

$PO_4 = 16{,}237$ tons $= 111{,}071 * 0.28 * 0.52 * 1.004$

$PO_5 = 2{,}008$ tons $= 16{,}237 * 0.28 * 0.44 * 1.004$

$PO_6 = 215$ tons $= 2{,}008 * 0.28 * 0.38 * 1.004$

(3) $L = 3.6$ months $= (3{,}977{,}290/13{,}392{,}015) * 12$

Therefore, a fiber cycle would only be able to produce the equivalent of just over three and half months of newsprint if only recovered fiber is used as an input. If the assumed maximum rate (using the linear extrapolation approach) of 44 percent is met then the fiber cycle would be able to generate enough recovered fiber to meet current newsprint demand for just over half a year. This illustrates that the fiber cycle could not be maintained indefinitely without relying on new sources of fiber input for making paper. Table 3 illustrates the longevity of the cycle for each grade under the current utilization rate and the maximum utilization rate.

Table 3- Longevity of a Recycled Fiber Cycle by Grade (months)

Grade	Baseline	Maximum
Newsprint	3.6	6.4
Printing and Writing	0.7	1.5
Containerboard	6.9	13.4
Tissue	5.4	17.1

Determining the Fresh Fiber Input Requirement

The next question explored is how much fresh fiber is required to maintain the fiber cycle for a given level of total fiber output for making paper. To better understand if there is any variation in input requirements as fiber is repeatedly recycled, the variation in fresh input for five cycles is mapped out. However, it is important to note that the fiber cycle is dynamic so the exact proportion of input requirements constantly varies depending on the quality of recovered fiber available and what it is being used to produce. The equation used to calculate fresh fiber input requirements when looking at each pass through the fiber cycle is as follows:

(1) $VF_i = TFO - 9\ RF_{i.c}$ where:

- VF_i = fresh fiber input for a given cycle;
- TFO = total fiber output; and
- RF_{ic} = the amount of recycled fiber recovered and reused from previous production cycles. Therefore, i is the number of cycles and c is the number of passes a piece of fiber makes.

Note that $RF_i = PO_{i-1} * UR * YR^i$.

The following example demonstrates the fresh input requirements necessary to maintain the fiber cycle for newsprint starting with an initial output of 1 million tons of paper. The total fiber output needed is approximately 996,000 tons and the utilization rate of recovered paper is 28 percent.

(1) $VF_2 = TFO - RF_{1.1}$

$VF_3 = TFO - \sum RF_{2.1} + RF_{1.2}$

$VF_4 = TFO - \sum RF_{3.1} + RF_{2.2} + RF_{1.3}$

$VF_5 = TFO - \sum RF_{4.1} + RF_{3.2} + RF_{2.3} + RF_{1.4}$

VF_2 = 758,045 tons = 996,016 – 237,971

VF_3 = 766,574 tons = 996,016 – 181,114 – 48,328

VF_4 = 767,740 tons = 996,016 – 183,152 – 36,781 – 8,342

VF_5 = 767,817 tons = 996,016 – 183,451 – 37,195 – 6,349 – 1,224

The average proportion of fresh fiber required to maintain the production of newsprint is 77 percent. Table 4 provides more insight into how the fresh fiber requirement by cycle is calculated. If the maximum utilization rate, using the linear extrapolation approach, is reached the fresh fiber input requirement falls to 64 percent.

Table 4- Estimating Fresh Fiber Requirement

Cycle 1						
Pass	Amount	Utilization Rate	Yield Rate	Reusable Fiber Yield	Nonwood Input Factor	Output
Fiber	996,016				1.004	1,000,000
First	1,000,000	28%	85%	237,971	1.004	238,923
Second	238,923	28%	72%	48,328	1.004	48,521
Third	48,521	28%	61%	8,342	1.004	8,376
Fourth	8,376	28%	52%	1,224	1.004	1,229
New Input Requirement Cycle 2						
Pass	Amount	Utilization Rate	Yield Rate	Reusable Fiber Yield	Nonwood Input Factor	Output
New Input	758,045				1.004	761,077
First	761,077	28%	85%	181,114	1.004	181,839
Second	181,839	28%	72%	36,781	1.004	36,929
Third	36,929	28%	61%	6,349	1.004	6,375
New Input Requirement Cycle 3						
Pass	Amount	Utilization Rate	Yield Rate	Reusable Fiber Yield	Nonwood Input Factor	Output
New Input	766,574				1.004	769,640
First	769,640	28%	85%	183,152	1.004	183,884
Second	183,884	28%	72%	37,195	1.004	37,344
New Input Requirement Cycle 4						
Pass	Amount	Utilization Rate	Yield Rate	Reusable Fiber Yield	Nonwood Input Factor	Output
New Input	767,740				1.004	770,811
First	770,811	28%	85%	183,431	1.004	184,164
New Input Requirement Cycle 5						
Pass	Amount	Utilization Rate	Yield Rate	Reusable Fiber Yield	Nonwood Input Factor	Output
New Input	767,817				1.004	770,888

The analysis of the other grades employs the relevant variables listed in Table 1 and the equations presented earlier in the report (pages five through seven) to determine the fresh fiber input required to sustain each grade under different recovered paper utilization scenarios. The results are presented in Table 5. As the case for tissue indicates some fresh fiber component is still required for each grade even if the grade utilization rate is 100 percent. This is due to the technical decline that results from transforming recovered paper into a reusable fiber input.

Table 5- Estimating Fresh Fiber Requirement by Paper Grade

Scenario	Baseline		Maximum Recycled	
Grade	**Utilization Rate**	**New Fiber Input**	**Utilization Rate**	**New Fiber Input**
Newsprint	28%	77%	44%	64%
Printing & Writing	7%	95%	14%	89%
Container	43%	63%	66%	45%
Tissue	46%	68%	100%	37%

It is also important to note that a 100 percent rate might not be attainable across all grades that fall under the tissue category. While institutional tissue products are moving in the direction of 100 percent recovered paper content, home tissue products are incorporating more fresh fiber. This is due to the fact that recent technologies offer fiber efficiency gains that cannot be attained used recovered fiber and that fresh fiber has properties that are more likely to meet the preference many tissue customers have for softness. Nevertheless, this report focuses on material balances and discussions on how different fiber mixes meet consumer preferences is beyond the scope of the study.

The Material Implications of Shifting Recovered Paper Supply

The material balance implications evaluation attempts to determine the system-wide effects for different scenarios where recovered fiber supplies are shifted to particular grade to meet a certain post consumer content average, while overall supplies remain unchanged. There are limits to substituting recovered paper supplies across grades. For example, old corrugated containers are not used for making new printing and writing grades due to performance concerns. Table 6 provides insight into estimated flows of recovered paper products to the production of new paper grades.

Table 6- Estimating Recovered Paper Flows (tons)

Recovered Paper	From Newsprint	From Printing & Writing	From Container-board	From Other Grades	Total
To Newsprint	3,917,128	291,733	0	0	**4,208,861**
To Printing & Writing	350,249	1,576,312	0	0	**1,926,562**
To Container	11,589	0	16,134,626	0	**16,146,215**
To Tissue	906,534	2,905,040	144,172	0	**3,955,747**
To Other Grades	1,894,013	3,915,939	5,115,653		**12,262,579**

Printing and Writing Scenario

This scenario examines the limitations and implications of shifting recovered paper supplies to printing and writing papers. While such shifts have environmental and economic effects, the analysis only examines the material balance implications.

As Table 6 indicates, mostly recovered printing and writing and a small amount of recovered newsprint8is used in making new printing and writing grades. Further, most recovered printing and writing papers are used as recycled content for other grades. The reasons for this are economic and technical as many recovered papers lack the properties necessary to make them technically feasible to be utilized as recycled content for new printing and writing papers.

Nevertheless, to illustrate the material implications of shifting recovered paper supplies this analysis assumes that there are no technical limitations to using all of the recovered printing and writing papers as reusable fiber for making new printing and writing products.

Under this scenario, approximately 7.2 million tons of recovered printing and writing paper are shifted from newsprint[8], tissue and other grades to printing and writing grades. Of this amount, 55 percent would have gone to other grades such as containers and boxboard, 41 percent would have gone to making tissue and four percent would have been used for making newsprint.

Although this shift raises the recovered paper utilization rate from seven percent to 28 percent, it results in a net loss of total reusable fibers produced in Canada and the United States. Table 7 reveals that such a shift would result in additional 5 million tons of reusable fibers for printing and papers, but at the cost of almost 6.7 million tons that would have been used as recycled content in other grades of paper.

Table 7- Recovered Paper Supply Scenarios (tons)

Table Head	Yield Loss	Baseline Scenario		Printing & Writing Scenario		Material Effect
		Recovered Paper Use	Reusable Fiber	Recovered Paper Use	Reusable Fiber	Net Change
Printing & Writing	30%	1,926,562	1,348,594	9,069,189	6,348,432	4,999,838
Newsprint	15%	4,543,413	3,861,901	4,251,680	3,613,928	-247,974
Tissue	25%	4,033,172	3,024,879	1,128,132	846,099	-2,178,781
Other	12%	28,563,312	25,135,714	24,647,373	21,689,689	-3,446,026
Total		**39,096,373**	**33,392,028**	**39,096,373**	**32,498,147**	**-872,942**

[8] Less than five percent of recovered newsprint is used as recycled content for printing and writing papers.

Annex: Peer review process

Metafore hired Pyramid Communications to facilitate a third-party review of the Fiber Cycle Technical Document. Pyramid contracted with three outside experts, Jim Bowyer, Bill Moore and John Polak (see bios below) to conduct the review. None of the reviewers were involved in development of the original document. Overall, reviewers felt the basic approach used in the report was good and the calculation methods sound.

Because of the technical nature of the document, reviewers suggested it is most appropriate for a technically sophisticated audience with existing knowledge of key terms and calculation methods. In addition, the technical document should be considered along with other supporting documents.

One issue raised by reviewers is the absence of recycled paperboard in the document. These product grades (including boxboard and construction products) are major users of all grades of recycled fiber and have some of the highest yields of all recycled grades – possibly exceeding 95%.

In summary, reviewers felt the paper addressed an important topic about which there is a great deal of confusion. As such, it is an effective tool for understanding the dynamics involved in fiber recycling.

Reviewers

Dr. Jim L. Bowyer

Dr. Jim Bowyer is a professor within the University of Minnesota's Department of Bio-based Products and a professional consultant. He is an Elected Fellow of the International Academy of Wood Science, Chairman of the Tropical Forest Foundation, Chairman of the Minnesota Bio-Fiber Council, and Governing Board member and Chairman of the Scientific Advisory Board of the Temperate Forest Foundation. He is Past President of the Forest Products Society (93-94), and Past President of the Society of Wood Science and Technology (87-88), and Vice President of the Consortium for Research on Renewable Industrial Materials (CORRIM) from 1992-2003. He served as Project Leader of the Minnesota Agricultural Experiment Station project "Environmental Life Cycle

Assessment of Bio-Based Materials and Products" from 1988 to 2003, and led a research team focused on global raw material consumption and supply trends over a 30-year period. Bowyer has published over 240 articles dealing with wood science and technology, environmental life cycle analysis, and environmental aspects of forestry, timber harvest and wood use.

William P. Moore

Mr. Moore is president of Moore & Associates, an international consulting firm engaged in providing a range of strategic services to the paper recycling industry. Prior to his six years as a consultant, he held a series of positions in the solid waste, paper and recycling industries. These included founder and vice president of Paper Recycling International (a joint venture of Stone Container) and director of recycling for Waste Management, Inc. He was responsible for the startup of Waste Management's "Recycle America" program, the largest introduction of recycling services in the United States. Mr. Moore's knowledge base includes all aspects of the worldwide supply and demand of recovered paper.

John Polak

Mr. Polak is a Professional Engineer with over thirty years of experience in the environmental sector and at the senior management level. In July 1995, Mr. Polak created TerraChoice Environmental Marketing Inc. and is currently its Chairman. TerraChoice is in the business of marketing reliable science. Since customers rely on TerraChoice's credibility, it is protected as the company's most valuable asset by adhering to key principles and practices. He has worked on issues related to transportation, air pollution and energy for Environment Canada, environmental management in the Yukon, development assistance delivery at CIDA, international environmental policy and environmental labeling. He has authored technical and policy papers, including a number related to environmental labeling, trade and change management and has addressed the WTO, UNCTAD, OECD and UNEP on the subject of eco-labeling and trade. Domestically, he has managed voluntary and regulatory environmental programs, both from Ottawa and in provincial and territorial capitals.