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APRIL 19, 2019

TO: GreenBlue

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SUBJECT: Fiber Cycle Longevity and Fresh Fiber Requirements for the North American Paper and Board Industry

NCASI updated the results of "The Fiber Cycle Technical Document[1]", authored by Metafore and based upon 2005 data, with 2016/17 information. Between 2005 and 2016 there have been substantial production changes in the North American paper and board industry, with an approximately 63% reduction in newsprint production, a 48% reduction in printing and writing production, and a 57% increase in containerboard production. Given that these production changes may influence the current applicability of results in the Metafore document, the results on the longevity of the fiber cycle (the amount of time the fiber cycle would operate ***in the absence of fresh fiber***), and the required amount of fresh fiber to maintain current operating levels in North America, were updated with the latest statistical information on the North American paper and board sector.

Definitions, equations, and data sources and numbers used in calculations are provided in Appendix A. Table 1 provides updated fiber cycle longevity results. The weighted average fiber cycle longevity is 6.1 months for the North American paper and board industry, meaning that the North American fiber cycle would be devoid of fiber in about six months without the constant input of fresh fiber. The weighted average fiber cycle longevity from the Metafore document was 4.0 months, but the shift from grades with lower utilization rates (newsprint and printing & writing) to higher utilization rates (containerboard and tissue), as well as improved grade utilization rates has extended the fiber longevity for the North American paper and board sector by approximately two months. When using maximum utilization rates in Appendix A for major grades, the weighted average fiber cycle longevity is 10.9 months. Fiber cycle longevity calculations are based upon annual statistics and are therefore conservative because they assume that there is a year's worth of product inventory that can be used to supply the fiber cycle. In actual practice, fiber inventories are much less than a year's supply of inventory, so the fiber cycle would cease to function more rapidly than is shown in Table 1 if fresh fiber were eliminated from the fiber cycle.

[1] hereafter termed the "Metafore document" (Metafore 2006)

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Table 1. Longevity of the North American Recycled Fiber Cycle by Grade (Months)

Grade	At Current Utilization Rate	At Maximum Utilization Rate
Newsprint	0.8	6.4
Printing and Writing	0.6	1.5
Containerboard	8.1	13.5
Tissue	7.2	17.1
Weighted average for all grades	**6.1**	**10.9**

Table 2 shows the fresh fiber input required the maintain the North American fiber cycle at its current levels. At current utilization rates, 66% of the fiber cycle needs are met with new fiber input. At maximum utilization rates, fresh fiber will still be required to meet over half of the total fiber cycle requirements.

Table 2. Fresh Fiber Requirements by Major Grade

	Current		Maximum	
	Utilization Rate	New Fiber Input	Utilization Rate	New Fiber Input
Newsprint	8%	93%	44%	65%
Printing and Writing	6%	81%	14%	96%
Containerboard	48%	58%	66%	46%
Tissue	57%	63%	100%	42%
Weighted average for all grades	**38%**	**66%**	**57%**	**53%**

APPENDIX A

Longevity of the fiber cycle in months

The longevity of the fiber cycle, i.e., the amount of time the fiber cycle would operate ***in the absence of fresh fiber***, was determined using the equations used in the Metafore document, which assume that fiber can be recycled six times before it becomes unusable, and a declining fiber yield equation based upon the number of times the paper or board has been recycled. These equations can be derived from Figure 1, which is a modified mass balance for domestic recycle fiber production assuming no fresh fiber input. Terminology in Appendix A is consistent with terminology used in the Metafore document.

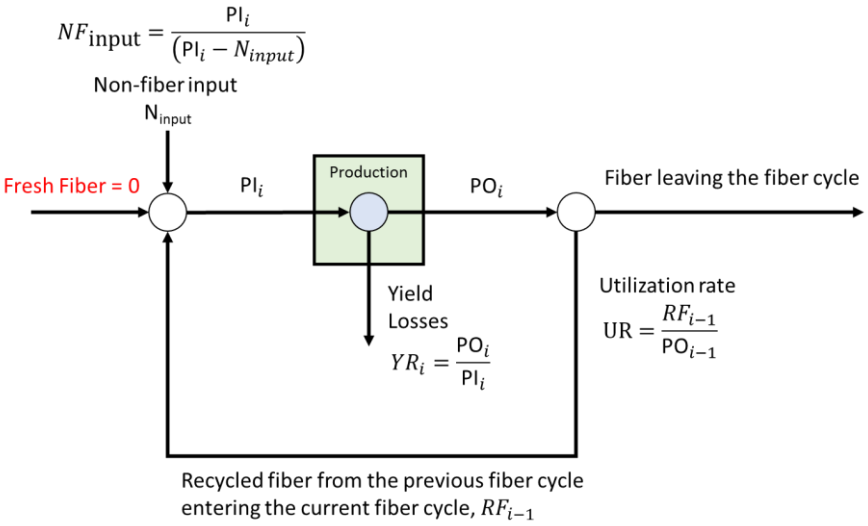

Figure 1. Fiber cycle mass balance for cycle i

The paper output for cycle *i* is:

$$\text{PO}_i = \text{PO}_{i-1} \cdot \text{UR} \cdot \text{YR}_i \cdot \text{NF}_{\text{input}}$$

PO_i: Paper output for cycle *i*
UR: Recovered paper utilization rate (the amount of recovered paper used for domestic paper and paperboard production as a percentage of total domestic paper and paperboard production).
YR_i: Yield rate for each successive reuse of fiber
NF_{input}: A factor to estimate the portion of non-fiber input in paper products, e.g., NF_{input} = 1.1 implies that non-fiber inputs are 10% by weight of the paper product

Total annual paper output from recovered fiber can be obtained by summing the paper output for all (six) paper cycles.

$$\text{TPO} = \sum \text{PO}_i$$

TPO: Total cumulative paper output from using recovered fiber
i: The number of times the fiber is recycled

The longevity of the fiber cycle is the ratio of the cumulative paper output from recovered fiber to the production consumption. As in the Metafore document, annual statistics are used because they are the numbers most readily available. Using annual statistics for calculation of fiber longevity is conservative because the approach assumes one year's worth of product inventory can be used to supply the fiber cycle.

$$L = (\text{TPO}/\text{CONS}) \cdot 12$$

L: The longevity of the fiber cycle in months
CONS: Annual production

Required fresh fiber to maintain the fiber cycle at a given level of total fiber output for paper

$$\text{VF}_i = \text{TFO} - \sum_{\substack{i=n,\ldots,1 \\ c=1,\ldots,p}} RF_{i,c}$$

VF_i: Fresh fiber input for a given cycle
TFO: Total fiber output
$\text{RF}_{i,c}$: The amount of recycled fiber recovered and reused from previous production cycles, where *i* is the number of cycles and *c* is the number of passes a fiber makes.

To make use of the equations, major grade data are required for production (PO_1 and CONS), utilization rates (UR), yield factors (YR), and non-fiber input factors (NF_{input}). The latest available (2017) US paper and board statistics are taken from AF&PA (2018). Production statistics and the necessary data to calculate utilization rates at a national and major grade level are also available in various public sources (FAO 2017; FAO 2019; Howard et al. 2016; and Skog et al. 2011). Canadian information in Table 3 were taken from FAO (2017; 2019). Maximum utilization rates, yield factors, and non-fiber input factors are considered relatively constant and have therefore been retained from the Metafore document and are provided in Table 4.

Table 3. Paper Grade Variables for the United States, Canada, and North America [United States + Canada] (2016-2017 data)

Variables	Newsprint	Printing & Writing	Containerboard	Tissue	Sum and Weighted Average
United States (2017 data)					
Production (1,000 mt)	1,195	12,971	46,328	6,888	67,382
Domestic Utilization Rate of Recovered Paper (%)	7%	6%	48%	55%	40%
Canada (2016 data)					
Production (1,000 mt)	3,350	3,000	3,050	700	10,100
Domestic Utilization Rate of Recovered Paper (%)[a]	6%	7%	57%	68%	26%
North America (2016/17 data)					
Production (1,000 mt)	4,545	15,971	49,378	7,588	77,482
Domestic Utilization Rate of Recovered Paper (%)	8%	6%	48%	57%	38%

a) Recovered paper data at the major grade level were not available for Canada (FAO 2019); therefore, the grade utilization rates were assumed to be equivalent to the United States and scaled so that the weighted average utilization rate equaled the country utilization rate reported in FAO (2019).

Table 4. Other Paper Grade Variables[2]

Variables	Newsprint	Printing and Writing	Containerboard	Tissue	Sum and Weighted Average
Maximum Utilization Rate of Recovered Paper	44%	14%	66%	100%	57%
Yield Factor	85%	70%	88%	75%	83%
Non-fiber Input Factor	1.004	1.166	1.019	1.001	1.05

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[2] From “The Fiber Cycle Technical Document”, Metafore 2006