Comparative Life Cycle Impact Analysis of TENCEL® and Modal versus Viscose Asia

November 13th, 2017

Analysis Overview

- The objective of this study is to compare the impact of the Tamga's Tencel and Modal clothing against Viscose clothing. The findings of the study are intended to be used as a basis for communication and marketing. The primary audience for this study is Tamga, its investors and customers.
- This cradle-to-gate comparative life cycle inventory (LCI) encompasses clothing lifecycle from raw material acquisition to fibre and fabric manufacture and transport. All the relevant life-stages of Tencel, Modal and Viscose Asia clothing are analyzed to estimate the net impact across five key impact metrics: GHG emissions, energy use, toxins, trees & land use and water consumption.
- This analysis does not include impact assessment. It does not attempt to determine the fate of emissions, or the relative risk to humans or to the environment due to emissions from the systems. An exception is made in the case of global warming potential impacts which are calculated based on internationally accepted factors for various greenhouse gases' global warming potentials relative to carbon dioxide.

Scope of the Study

- Functional unit was taken as 1 kg of finished cloth fabric.
- The study examined Tencel and Modal fibre manufacturing in Austria and Viscose fibre manufacture in Indonesia for Lenzing. Yarn manufacture and fabric manufacture was in Indonesia. Transportation between the various plants up until fibre manufacture was also taken into account
- Dyeing was not part of the study due to insufficient data

System Boundary

TENCEL® and Modal	Viscose Asia
Fibre production at Lenzing, Austria	Fibre production in Indonesia
Land and ocean transport from Austria to Indonesia	Land transport from fibre manufacture to mills
Yarn manufacture	Yarn manufacture
Land transport from yarn manufacture to textile mills	Land transport from yarn manufacture to textile mills
Fabric manufacture	Fabric manufacture

Fabric steaming

- Steam for fabric is one of the most material lifecycle stages in the study. In general fabric steaming in Asia is done using coal power. The energy used and resulting emissions from coal combustion in Indonesia was separately modeled using the GaBi platform.

Other data

- Transportation distances were modeled using Tamga inputs and Lenzing plant locations and ThinkStep databases on manufacturing plant locations.
- Energy use for Yarn and Fabric manufacture was modeled using Tamga inputs

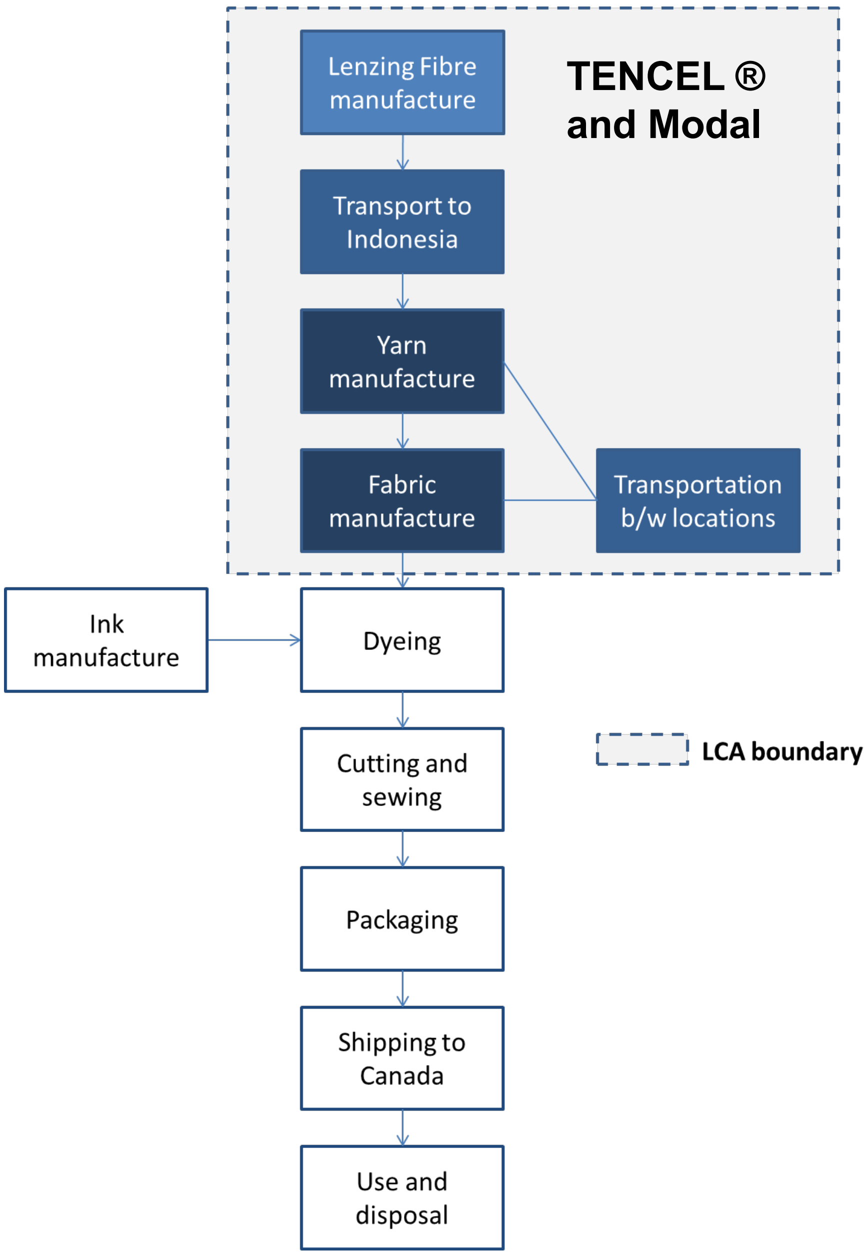
Data Audit

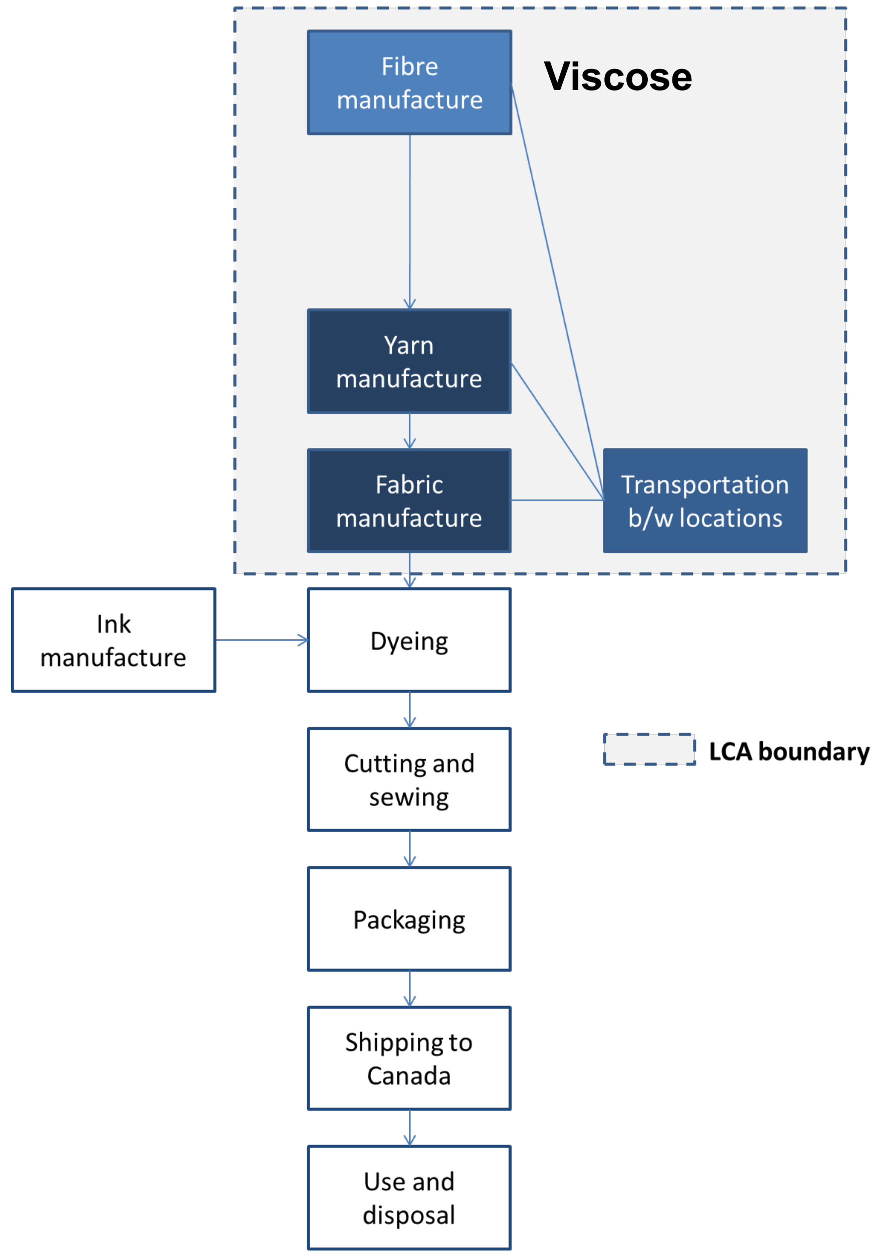
- No internal or external audit of resource utilization data provided by Tamga was performed by Green Story for this study. It is assumed that data provided by Tamga and its suppliers is factual and accurate.

Critical Review

- No third-party critical review has been performed for this study.

TENCEL® and Modal vs. Viscose Study Boundaries





TENCEL® AND MODAL VS. STANDARD VISCOSE ASIA COMPARATIVE IMPACT

Key Assumptions

Transport:

  - Fibre: Total shipping distance was calculated at 6,513 Nautical miles based on closest port to Lenzing Austria plant and closest port to plant in Boyalali
  - It was assumed that land transportation was by truck from plants to ports in Austria and Indonesia and between plants in Indonesia
- In the absence of process data of steam creation from coal used in fabric manufacturing in Indonesia it is assumed to use the same technology as in India
- Dyeing has not been modeled and is considered out of scope for the report
- Post-fibre creation, all processes until fabric manufacture (except transportation) are assumed to be same for all three fabrics

TAMGA's TENCEL® and Modal Clothing vs. Standard Viscose Asia Comparative LCI (per kg of clothing)

Net Impact Difference (Tencel/Modal – Viscose)

Per kg	Energy MJ	Emissions kgCO2e	Water L
Modal	29.2	3.9	55.5
Tencel	42.7	3.9	78.5

Net Impact Equivalence (Modal)

135 hours of light bulb energy saved

15 km of car driving emissions avoided

32 days of drinking water for a person saved

Net Impact Equivalence (Tencel)

197 hours of light bulb energy saved

15 km of car driving emissions avoided

46 days of drinking water for a person saved

TAMGA's TENCEL ® & Modal Clothing vs. Standard Viscose Asia Comparative LCI (per average garment of 0.250g)

Net Impact Difference (Tencel/Modal – Viscose)

Per avg garment	Energy MJ	Emissions kgCO2e	Water L
Modal	7.3	1.0	13.8
Tencel	10.7	1.0	19.6

Net Impact Equivalence (Modal)

34 hours of light bulb energy saved

4 km of car driving emissions avoided

8 days of drinking water for a person saved

Net Impact Equivalence (Tencel)

49 hours of light bulb energy saved

4 km of car driving emissions avoided

12 days of drinking water for a person saved

TAMGA's Energy impact by Life Cycle Stage

MJ/kg	Total	Fibre manufacture	Fibre to Yarn Transport	Yarn manufacture	Yarn to Fabric Transport	Fabric manufacture	
						Steam	Electricity
Modal	**1182.12**	87.04	4.31	79.46	0.13	970.39	20.48
Tencel	**1168.62**	73.48	4.11	79.46	0.40	970.39	20.48
Viscose	**1211.28**	119.82	0.42	79.46	0.40	970.39	20.48

Process similarities

- All 3 fibres have the same processes after initial fabric procurement.
- The major impact in each of the cases came from steam usage at the fabric manufacturing stage

Transport

- The major primary energy demand difference between viscose and Modal/Tencel other than fibre manufacture stage comes from transportation stage.
- Transport energy use for Tencel and Modal are modeled as being higher due to transport required from Austria to Indonesia
- Transport for viscose Asia has been assumed to be local within Indonesia

TAMGA's Emissions Impact by Life Cycle Stage

kgCO2e/kg	Total	Fibre mfg.	Fibre-Yarn Transport	Yarn mfg.	Yarn-Fabric Transport	Fabric manufacture		
						Steam	Electricity	Diesel
Modal	**105.75**	0.11	0.23	6.89	0.11	96.46	1.77	0.18
Tencel	**105.66**	0.03	0.33	6.89	0.01	96.46	1.77	0.18
Viscose	**109.65**	4.30	0.03	6.89	0.03	96.46	1.77	0.18

Process Similarities

- As emissions have largely been derived from energy use, the results are similar with both Tencel and Modal having very similar emissions profiles
- The major difference from viscose stems from lower transport emissions for viscose due to manufacture in Indonesia and higher fibre manufacture footprint

TAMGA's Toxicity Impact

Toxicity	Viscose	Modal	TENCEL®
Human toxicity (kg 1.4-DB eq.)	1.96	0.77	0.66
% lower than viscose		61%	66%
Fresh water aquatic ecotoxicity (kg 1.4-DB eq.)	0.438	0.093	0.075
% lower than viscose		79%	83%
Terrestrial ecotoxicity (kg 1.4-DB eq.)	0.0495	0.016	0.0046
% lower than viscose		68%	91%

Overall

- The typical measurement of toxicity is in terms of the carcinogen 1,4 dichlorobenzene equivalent.
- The important contributors to toxicity are the production of chemicals such as magnesium oxide, caustic soda, and hydrogen peroxide, of CS2 production, of sulphur production plus the external electricity use and some CS2 emissions (even though majority of it is converted into by-product and not released to the environment).
- There are also upstream impacts of fossil fuel generation, production of market pulp bought by Lenzing, and transportation which Lenzing does not control and contributes to toxicity

Tencel

- As can be seen, both Tencel and Modal release significantly lower toxins.
- Tencel avoids most of these harmful chemicals but has emissions from the waste incineration plant, where energy is recovered and provided to the production of Tencel Austria and also from upstream transportation, chemicals production, electricity and fossil fuel manufacture.

TAMGA's Land-Use and Tree-Use Impact

Land Use	TENCEL®	Modal	Viscose
Hectare/year/ton of fibre	0.22	0.70	0.69
Oven dried ton/ton of fibre	2.17	2.38	2.35
Pine Trees/ton of fibre	1.36	1.50	1.48

Tencel has lowest land use impact

- Land use metrics were modeled based on the typical land use in harvesting the jack pine tree
- There might be slight variations in actual usage as the materials in question use European hardwood, and Southern Eucalyptus trees
- The impact of not sourcing from old-growth forests has not been modeled in the land use scenarios

Tree sourcing

- Lenzing Viscose Austria, Lenzing Modal and part of Tencel Austria are produced from the Lenzing pulp, which originates from beech wood.
- Half of the beech wood comes from Austria and most of the other half is from other European countries.
- The market pulp used for Lenzing Viscose Asia and Tencel Austria is based on eucalyptus wood produced in the southern hemisphere.

TAMGA's Water Impact

Water Footprint (Litres/kg)	TENCEL®	Modal	Viscose
Wood growing stage (green water)	26	26	124.5
Fibre Processing (blue water)	20	43	
Total Water	46	79	124.5

1. Cooling water during the manufacture is not considered in the water impact as it has been assumed that cooling water is returned back to same source without any effluents
2. Only data up to the fibre gate stage has been considered for this analysis
3. Wood growing stage water impact of 26 L/kg is back calculated based on two separate Lenzing studies. One study provides the total Tencel fibre impact of 46 L/kg and other study provides the process water impact of 20 L/kg
4. TENCEL® and Modal fibre are assumed to use the same wood source. Hence the same wood growing stage water impact for both fibres
5. Grey water footprint is not considered for the purpose of this study

List of Sources

- **Secondary Sources**
  - Li Shen and Martin K. Patel, LIFE CYCLE ASSESSMENT OF MAN-MADE CELLULOSE FIBRES, Lenzinger Berichte 88 (2010) 1-59
  - Comparing life cycle energy and GHG emissions of biobased PET, recycled PET, PLA, and man-made cellulosics
  - http://www.wood-database.com/jack-pine/
  - Power in Indonesia, Investment and Taxation Guide, November 2016
  - Viscose Fibres sustainability, Water Footprint Network, August 2017
  - Ecoinvent datasets
  - Thinkstep datasets
  - EPA equivalences: https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references
  - TENCEL, THE NEW AGE FIBER, SUSTAINABILITY SNAPSHOT, Lenzing, 2017
  - N. Terinte b, B.M.K. MandaEnvironmental assessment of coloured fabrics and opportunities for value creation: spin-dyeing versus conventional dyeing of modal fabrics, Journal of Cleaner Production, 2014
  - Water Footprint assessment of polyester and viscose and comparison to cotton, Water Footprint Network, March 2017
  - Mayo Clinic

- **Primary Sources**
  - Tamga supplier data
  - Tamga proprietary data

- **Ecoinvent Datasets**
  - Viscose fibres, at plant

- **Thinkstep Datasets**
  - GLO: Truck, Euro 5, 28 - 32t gross weight / 22t payload capacity ts <u-so>
  - GLO: Container ship, 27500 dwt payload capacity, ocean going ts <u-so>
  - EU-28: Heavy fuel oil at refinery (1.0wt.% S) ts
  - EU-28: Diesel mix at filling station
  - CN: Diesel mix at filling station
  - IN: Process steam from hard coal 85% ts

About Green Story

The Green Story team is led by Akhil Sivanandan and Navodit Babel. Both members received their sustainability reporting training from the Global Reporting Initiative.

- Navodit has 10+ years of experience in consulting and product management with global corporations. He has successfully overseen the launch of national card strategies in Canada. During his MBA at the University of Toronto, he developed a sustainability ranking algorithm for mining projects for Sustainalytics which used in the company's global operations.

- Akhil has worked on sustainability projects for companies such as Philips Lighting and given presentations and interviews on the topic for multiple publications including the New York Times. He was also intimately involved in the Ontario Cap and Trade and Offsets programs as part of the Government. Akhil received his MBA from the University of Toronto.

Green Story's mission is help companies communicate environmental and social impact to stakeholders in a clear, credible and relatable manner.

We work with a range of companies from waste management firms to one of North America's largest bottled water manufacturers to engage stakeholders and measure and communicate impact.

Green Story is a Ministry of Environment Agent of Change, Social Capital Markets scholarship recipient, a member of the MaRS Centre for Impact Investing and of Ryerson University's Social Venture Zone

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