Textile Remanufacturing and Energy Savings

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1 Introduction

As per the US EPA [1], close to 5% of the total municipal solid waste generated in the US are textiles. This corresponds to 12.5 million tons in weight. One way to avoid this waste is to recycle textiles. Textile recycling can be done in two ways - (1) recycling the discarded textiles back into the market; and (2) disintegrating the textiles to its bear fibers and using them for other applications, including production of new textiles. In this report we look at scenario (1) which preserves not only the energy invested in the production of the fibers but also the energy consumed in manufacturing the textiles. In terms of waste, textile waste is classified into pre-consumer and post-consumer waste. Pre-consumer waste is that generated by the textile industries, and is created prior to the consumption stage. On the other hand, Post-consumer textile waste consists of all types of garment or household articles made of textiles that the owner no longer needs and decides to discard [3]. These articles are discarded either because they are worn out, damaged, outgrown, or have gone out of fashion. In report we only focus on recycling post-consumer textile waste back into market. Textile recycling is not a new concept, in fact [3] reports that the textile recycling industry annually prevents 2.5 billion pounds of postconsumer textile product waste from entering the solid waste stream. Nearly half of textiles discarded are contributed to charities, according to an estimate from the Council for Textile Recycling [1]. Charities either give away clothes or sell them at discounted prices in secondhand stores. About 61 percent of the clothes recovered for second-hand use are exported to foreign countries.

Thus clearly there exists a market and demand for reused textiles within and outside the nation. It is hence essential to evaluate the environmental impact of this activity. In this study we estimate the environmental footprint by the total energy consumed over the life cycle of the product. Since reusing a product primarily extends its life-cycle, it helps avoid the production of new. Thus the energy savings are derived with reference to the decision of using new textiles.

2 Methodology and Data Sources

The methodology adopted is the same as that for the other case-studies. Life-cycle assessment (LCA) is the major tool used. The boundary of analysis for LCA includes primarily four phases:

- Material - The energy used to process the raw materials into usable form. This would entail the production of fibers.
- Production - The energy used in manufacturing the clothes which includes stitching, embroidering, printing, packaging etc.

- Distribution - The energy entailed in the distribution of the textiles to the consumer.

- Use - Use of the fully manufactured product by the consumer. For clothes it includes washing and ironing.

- End of Life - The energy consumed / recovered during the final stage of the product life. This could take several forms such as remanufacturing, recycling, reuse, incineration, landfilling etc.

The primary sources of data are [2, 5]. [2] is a report prepared by the Institute of Manufacturing at the University of Cambridge, which provides information for the materials, production, distribution and end of life energies for new textiles. [5] studies and hint of the energy requirements to extend the life of textiles by recycling it for various applications. Note again, recycling here refers to recycling the used textiles back into the market, and not the conventional definition of recycling which involves shredding, separation etc.

3 Scope of the Study

This study looks into evaluating the energy saving potential of remanufacturing textiles, so as to (a) save on the energy restored during material processing, textile production and distribution; (b) avoid landfilling of textiles which causes environmental degradation. In order to do so, the relative life cycle energy inventories for new and reused textiles is estimated. Textiles by itself is a broad term and is defined as any type of material made from fibers or extended linear materials such as thread or yarn [4]. In this report two types of textiles are looked at:

- A cotton t-shirt

- A viscose blouse

4 Life Cycle Assessment

4.1 New Textiles

As mentioned before, life cycle energy intensities for a new t-shirt and blouse were obtained from [2]. The t-shirt is made of single-jersey combed cotton, while the blouse is of man-made viscose. Figure 1 gives the life cycle inventories for the two.

The use phase of the t-shirt includes 25 washes at 60 ^{o}C followed by tumble drying and ironing, while the use phase of the blouse 25 washes at 40 ^{o}C followed by hang drying and no ironing. This difference in these

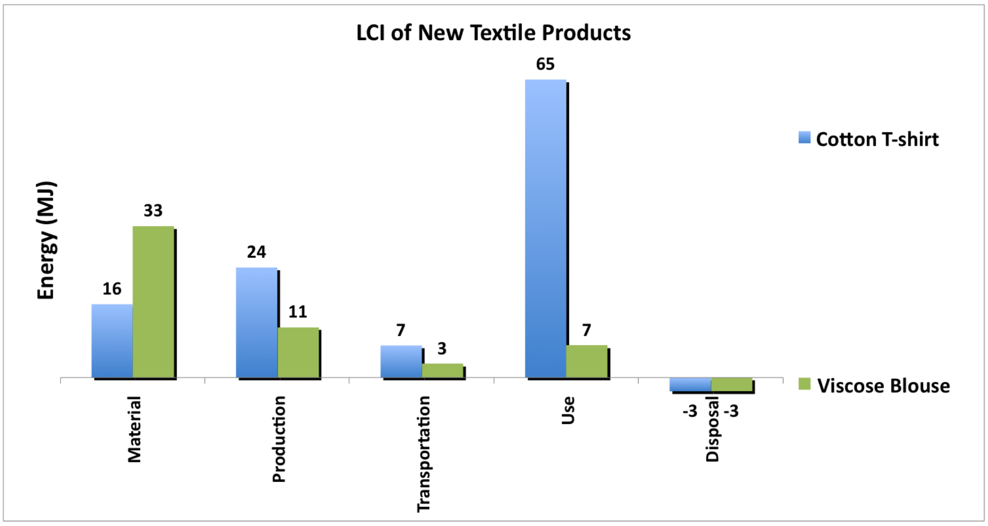


Figure 1: Life cycle inventories of a cotton t-shirt and viscose blouse [2].

maintenance requirements creates a huge difference in the use phase energy requirement. In the case of a t-shirt, the use phase consumes close to 60% of the total life cycle energy, while in the case of the blouse it is only approximately 14%. This makes the use phase to be the dominant phase for the t-shirt, while material production to be the dominant phase for the blouse. It should be noted that 25 washes per life of the garment is a conservative number, but is adopted to conform with [2]. Also the disposal phase for both the garments involves incineration, leading to heat production.

4.2 Old Textiles

[5] comprehensively estimate the quantity of energy used by a reusing textiles at the Salvation Army Trading Company Limited (SATCOL). SATCOL recycles clothing and textiles by providing a collection and distribution infrastructure for donated second hand clothing, textiles, shoes and accessories. It collects, sorts, balls and transports the reusable textiles and clothing to the parts of the world where there is a demand [5]. As per the report, it takes approximately 18 MJ per kg of clothing / textiles, in total, to do so.

Using this and the weight of the products under study from [2], the energy needed to reuse the products was estimated to be 4.5 MJ for the t-shirt and 3.6 MJ for the blouse. This is the energy consumed until resale of the products. Once sold, it is assumed that the product is used just like a new and its end of life options are the same as well (i.e. it is incinerated).

5 Life Cycle Energy Comparison

Using the above information, Figure 2 compares the energy footprint of using a new textile with that of reusing an old one. Clearly in both cases, there are tremendous amount of saving by reusing. In the case of the t-shirt, the savings are close to 40% while for the blouse they are higher than 85%. This difference is because of the different impact of the use phase on the total life cycle for the two products. Since the use phase of the new and reused textile remains the same, the % relative savings from materials and manufacturing are different for reusing a t-shirt and reusing a blouse respectively.

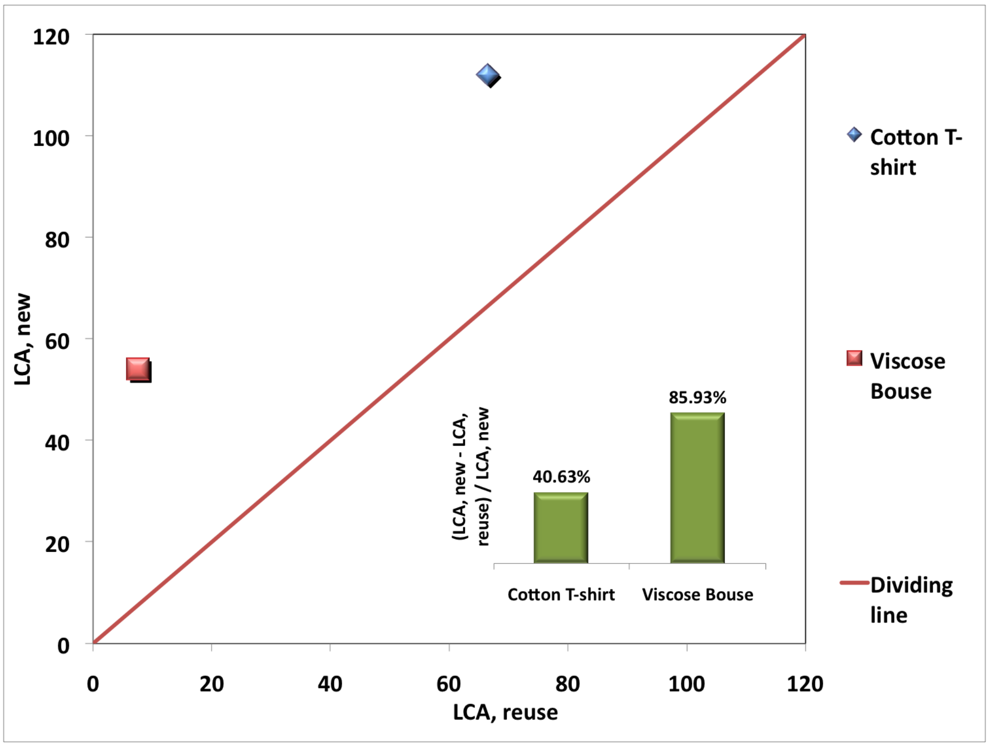


Figure 2: Comparing the life cycle inventories of a new and remanufactured t-shirt and blouse.

However, the overall conclusion is the tremendous energy saving that can be achieved by reusing textiles, or using them for a longer life-cycle than usual.

6 Assumptions and Comments

Most of the above study used refereed articles to procure data and information. However, there are a few assumptions made along the way which must be restated.

- The primary reports used - [2, 5] are studies based in the United Kingdom. It is thus assumed that the analysis for the U.S. is the same and the results are directly adopted.

- The estimate for energy to reuse textiles by [5] is a combined average for all textiles. In this report, the specific energy to reuse, for both the t-shirt and the blouse, is assumed to be this. In general the energy to reuse can be different for a t-shirt and a blouse, but it is not expected to deviate much from this average, since the two types of clothing considered are very similar. Moreover, since this energy per t-shirt / blouse is calculated to be relatively small (less than 5 MJ for both the t-shirt and the blouse), relaxing this assumption further is not likely to influence the conclusions drawn above.

- As mentioned before, the use phase for the reused textile is assumed to be the same as that of the new. This is at least true for the case when the consumer remains the same during the second life, but could change if the consumer changes. This variation is difficult to account for because of its high consumer specificity and is neglected.

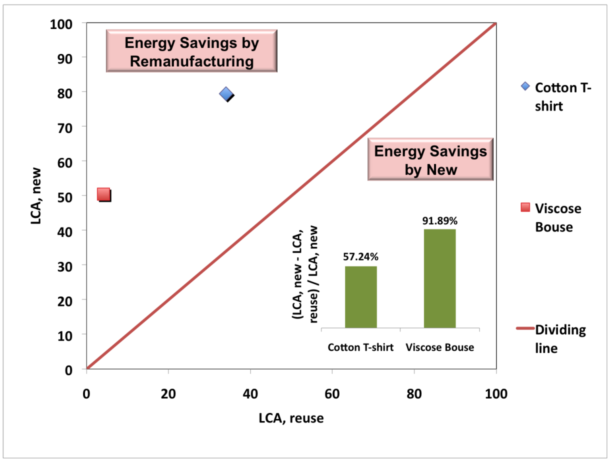
- It is also assumed that the reused product can be incinerated at the same rate as the new one. Hence, the end of life phase for the two is essentially the same.

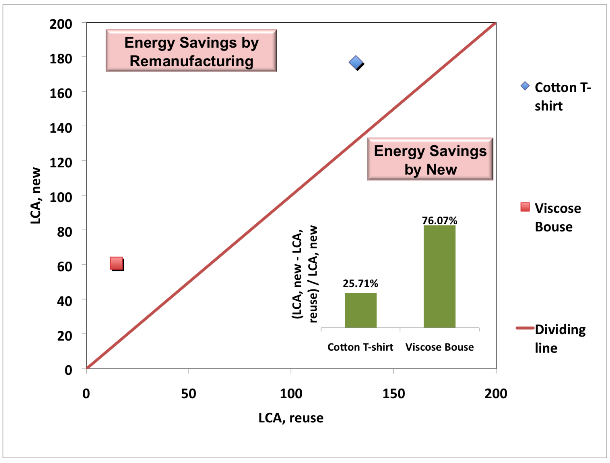
- The above report follows [2] and uses their use phase estimate for 25 wash cycles. Since the number of wash + ironing cycles can vary considerably from consumer to consumer, it is essential to do a sensitivity analysis for it. Figure 3 gives the result for 12, 50 and 75 wash cycles.

  The greater the number of wash+iron cycles, the greater is the use phase. Since the use phase for the new and the old textiles is the same, the % savings decreases with increased use phase. While for half the number of cycles considered in Figure 2, the savings for the blouse are over 91% and over 57% for the t-shirt, the savings are dwarfed to 68% and 19% respectively for thrice the number of cycles. However, even in the extreme case of 75 cycles, the saving from reusing textiles and clothing are significant and strongly recommend reuse of textiles.

7 Conclusion

In the above study the energy savings benefit of reusing clothing and textiles has been evaluated. Since the use phase involves washing, drying and ironing, the use phase varies considerably from consumer to consumer. As a


Energy Savings by Remanufacturing
Energy Savings by New
Cotton T-shirt
Viscose Bouse
Dividing line
LCA, new
LCA, reuse
(LCA, new - LCA, reuse) / LCA, new
57.24%
91.89%
Cotton T-shirt
Viscose Bouse


Energy Savings by Remanufacturing
Energy Savings by New
Cotton T-shirt
Viscose Bouse
Dividing line
LCA, new
LCA, reuse
(LCA, new - LCA, reuse) / LCA, new
25.71%
76.07%
Cotton T-shirt
Viscose Bouse

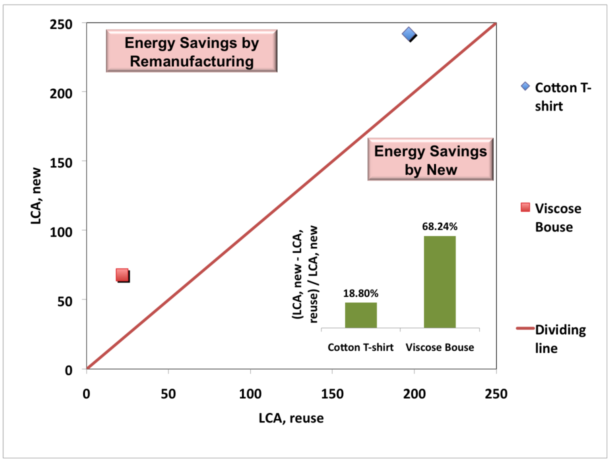


Figure 3: Comparing the life cycle inventories for a new and remanufactured t-shirt and blouse when the number of wash/iron cycles are (a) 12.5; (b) 50; (c) 75.

result several cases were considered for the use phase. All cases showed significant savings by reusing textiles. For approximately 12 wash/iron cycles in the life time of clothes, the savings are 57% for the t-shirt and 91% for the blouse. Even if the use is extended over six fold to 75 cycles, the savings are 19% and 68% respectively. Hence, the analysis strongly concludes that reusing textiles and clothing is the energy savings strategy.

References

[1] United States Environmental Protection Agency. Wastes - resource conservation - common wastes & materials. *Internet Source: http://www.epa.gov/osw/conserve/materials/textiles.htm*, 2008.

[2] Julian Allwood, Soren Ellebaek Laursen, Cecilia Malvido de Rodrigues, and Nancy M P Bocken and. Well dressed? the present and future sustainability of clothing and textiles in the united kingdom. *Institute of Manufacturing, University of Cambridge*, 2006.

[3] Council for Textile Recycling. Wastes - resource conservation - common wastes & materials. *http://www.textilerecycle.org/*.

[4] Nonwovens Innovation & Research Institute Ltd Oakdene Hollins Ltd, Salvation Army Trading Company Ltd. Recycling of low grade clothing waste. 2006.

[5] Anne C. Woolridge, Garth D. Ward, Paul S. Phillips, Michael Collins, and Simon Gandy. Life cycle assessment for reuse/recycling of donated waste textiles compared to use of virgin materials: An uk energy saving perspective. *Resources, conservation and recycling*, 46:94–103, 2005.