

It's Not Easy Being Green... Or Is It?

By Michael Tinneland

Fans await the arrival of various celebrities for a charity gala. Group after group of stars arrive in limousines or luxury sports cars. But then, what's this? One of the well-known stars at the event pulls up in a hybrid car, and soon after, another celebrity shows up in an all-electric car. People in the crowd are observing an evolution of chic—from excessive consumption to one of sustainability. *Goodbye mink coats and Rolls Royces, say hello to the new and “greener” chic!*

But a more environmentally aware social attitude is not just about celebrity or an appealing lifestyle. It is about decisions we make and the impact those decisions have on the environment. But when we want to get a complete view of the impact a product has on the environment, we need to look at a process called **Life Cycle Analysis (LCA)**. LCA examines every part of the production, use, and disposal of a product. This means looking at the collection and processing of the raw materials, the energy used in the production and use of the product, and the transportation and disposal (or recycling) costs.

A cup of comfort

Imagine stopping by your favorite coffee shop for a hot beverage. Is it more environmentally friendly to purchase coffee in a disposable paper cup or to bring your own ceramic mug, which can be washed and reused many times? It seems like an easy decision. Bringing your own ceramic mug has to be better than a disposable paper cup, right?

When we look a little deeper, the choice gets more complicated than it first appears. Let's start with the amount of energy it takes to produce once ceramic mug. **According to one LCA study, it takes 14 megajoules (MJ) of energy to produce one ceramic coffee cup. (A joule is a unit of energy that is equal to 2.39×10^{-4} kilocalories.)** By contrast, it only takes about 0.4 MJ of energy to produce a paper cup. (A Styro-foam cup uses only 0.2 MJ of energy.) This means that considering how much energy it takes to produce a paper cup, you would have to use a ceramic mug 35



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times to even out the difference in the energy to produce it over the paper cup ($14\text{MJ}/35 = 0.4\text{ MJ}$).

But there are other factors to consider, such as washing the ceramic mug. Even if the energy per use is decreasing every time you use the mug, you still have to add on the wash energy. Assuming the mug is washed after each use, it would take up to 1,000 uses of the mug to become less than the energy per use of a disposable cup. That would be like using the same mug every day for three years!

In the bag

What does LCA tell us about the option of “paper or plastic” at the grocery store checkout or about bringing a reusable cotton shopping bag? The obvious choice would be that a reusable cotton bag would be more environmentally friendly than one-use plastic or paper bags.

But cotton production has some well-documented environmental issues.

First, the cultivation of cotton is fossil fuel-intensive because it takes a great deal of tractor work to prepare fields and harvest the cotton.

Worse yet, conventionally grown cotton requires more pesticides than any other crop.



Also, the production of cotton bags releases more greenhouse gases than that of plastic bags. The production of a typical disposable plastic bag (assuming we only use it once) produces 27 grams of carbon dioxide equivalent per bag, while the production of a cotton bag releases 131 times that amount. A carbon dioxide equivalent is a quantity that describes, for a given mixture of greenhouse gases, the

amount of carbon dioxide that would trap the same amount of heat as the gases present in the mixture over a specific time interval—100 years in this case.

This means that a cotton bag would have to be reused 131 times more to be a greener choice. But what about reusable bags made of polyethylene or polypropylene? These turn out to be better alternatives at only 11 times disposable plastic. Less sturdy low-density polyethylene bags are even better at 4 times. We only gain ecological advantage if we actually use our reusable bags.

All bottled-up

Our last example concerns another consumer choice. Should we choose a disposable plastic bottle, a glass bottle, or an aluminum can when we buy a soft drink or other beverage?

A recent study measured the total energy to produce each product, greenhouse gas emitted, and solid waste produced. The study compared the containers on the basis of global impact for the number of containers required to each



Product	Total Energy (BTU*)	Greenhouse Gas (pounds of carbon dioxide equivalent**)	Solid Waste (pounds)
Plastic bottle	11.0	1,125	302
Glass bottle	16.0	2,766	767
Aluminum can	26.6	4,949	4457

Table 1. Total energy, greenhouse gas emissions, and solid waste created by plastic bottles, glass bottles, and aluminum cans that would each hold 100,000 ounces of beverage. *One BTU (British Thermal Unit) is the amount of heat needed to raise one pound of water by one degree Fahrenheit. **See the main text for the definition of a carbon dioxide equivalent.

hold 100,000 ounces of beverage. The results are shown in Table 1.

In each of the measures, the disposable plastic bottles more favorably impact the environment than either glass or aluminum containers. Glass containers are the heaviest containers of the three. This makes energy and greenhouse emissions larger for glass because heavy containers require more energy to transport and process. Aluminum is light, but the energy required for smelting and forming the aluminum containers adds to their numbers.



part of how we move toward a sustainable future. *CM*

SELECTED REFERENCES

- Live Cycle Perspective. U.S. Environmental Protection Agency: <http://www.epa.gov/nrmrl/std/lifecycle.html> [accessed Dec 2013].
- Life Cycle Assessment of Supermarket Carrier Bags: A Review of the Bags Available in 2006. Environment Agency's Evidence Directorate, United Kingdom: <http://a0768b4a8a31e106d8b0-50dc802554e-b38a24458b98ff72d550b.r19.cf3.rackcdn.com/scho0711buan-e-e.pdf> [accessed Dec 2013].

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A note of caution

We have chosen three examples showing that selecting a more environmentally friendly item is not as obvious when the total life of the product is examined. But this is not to say that every choice for a more sustainable option is other than it seems. LCA and other environmental tools can perhaps give us a better way to make decisions about how we can best produce and consume products.

Another issue that cannot be stated strongly enough is that assessments such as LCA are complex. Trying to evaluate every factor that goes into the environmental impact of a

product is complicated.

For example, we may dislike the way plastic bags litter our landscape and choose to ban them for that reason. The same might be true for soft-drink containers discarded on the beach. And one sea animal killed by eating a Styrofoam cup might be one too many. So, we may be willing to bear the environmental cost of reducing our use of these products because of other ways they impact our ecosystem. It’s a decision that must be made based on all available data and values.

Who knows? Maybe we are even willing to pay the price to have our celebrities keep their limousines. These decisions are all