LITERATURE REVIEW & INVENTORY

Greenhouse Gas Impacts of Disposable vs Reusable Foodservice Products

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CLEAN WATER FUND

ReThink Disposable
STOP WASTE BEFORE IT STARTS

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ReThink Disposable
STOP WASTE BEFORE IT STARTS

ReThink Disposable, created and implemented by Clean Water Fund (CWF), works in partnership with municipal stormwater and zero waste programs to engage food businesses and institutions (academic and corporate campuses) and consumers to minimize disposable take-out food and beverage packaging at the source to reduce plastics and trash that pollute our waterways and the ocean. This award winning program takes a pollution prevention approach to the ever-increasing problems of solid waste and marine debris. Based on research CWF conducted with five San Francisco Bay Area local jurisdiction partners in 2011, ReThink Disposable learned that food and beverage packaging is the primary component of trash (67%) entering the San Francisco Bay and polluting local creeks. Since 2012, ReThink Disposable has worked with more than 100 food businesses and five corporate and university campuses to reduce over 150,000 pounds of waste and the use of over 15 million disposable packaging items from food service operations, each year. Learn more at **www.rethinkdisposable.org**.

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Greenhouse Gas Impacts of Disposable vs Reusable Foodservice Products

Executive Summary

"Compostable" bioplastic foodware is marketed as "green" but in practice almost all is landfilled. Using bioplastic foodware (like PLA) that is landfilled yields no greenhouse gas reduction benefits. Hot and cold cups are the most studied foodservice product in terms of life cycle energy inputs and greenhouse gas impacts. Depending on the selected system boundaries, results vary widely. Improvements in dishwashing energy efficiency and changes in the electrical grid suggest that reusable cups have lower impacts than disposable cups in many situations. Reuse is far superior to recycling. A detailed study of drinking water delivery options showed that washing reusable water containers (glasses and bottles) has far lower global warming potential impacts than recycling single-use water bottles. Comparative life cycle studies of single-use versus reusable clamshells, plates, bowls and flatware have been less detailed than those for cups and water systems, but they generally reported low usage levels beyond which reusables have lower overall greenhouse emissions or energy usage than single-use products ("break-even points").

Introduction

Life cycle assessment (LCA) has risen to prominence in professional environmental circles in the past two decades. LCAs aim to quantify impacts of a product or service over its full "lifetime." Robust — and often costly — LCA software programs can evaluate dozens of impacts. While environmental impacts are typically the primary focus of analysis, social impacts can be considered as well. The focus of this literature review and inventory is environmental impacts relating to greenhouse gas emissions from extraction, manufacturing, distribution, consumption, and end-of-life management. Most recent LCAs directly assess greenhouse gas emissions, which are emissions from burning fossil fuels. They are typically reported in units of carbon dioxide equivalents, or CO2-eq, a measure used to compare emissions from various greenhouse gases based upon their global warming potential. Older studies report only energy usage (reported in British thermal units or in metric Joules). Energy usage can serve as a proxy for greenhouse gas emissions in the absence of direct measurements of the latter.

This review is further restricted to foodservice products, including cups, bowls, plates, cutlery, and clamshells. A limited number of LCA studies of foodservice products include energy or greenhouse gas metrics, and an even smaller number compare disposable with reusable products. Two trends stand out: (1) hot and cold cups have received the most attention, and (2) the entrance of plant-based "bioplastic" materials, such as polylactic acid (PLA), onto the food serviceware market has spurred LCA studies. Unfortunately, few LCA studies that compare compostable and non-compostable foodservice products also include analysis of reusable products.

The studies reviewed vary dramatically in scope, detail, relevance and quality. Several are non-peer reviewed university class projects. One difficulty noted by the most detailed LCAs is getting accurate information — or any information —

from manufacturers of covered products (e.g., Franklin Associates 2011b). Moreover, some of the more robust underlying data sets are from Europe and reflect conditions that may or may not be applicable to North America. Selection of "system boundaries" is another factor that varies widely between studies. One need only look at the divergent results for life cycle energy usage and greenhouse gas impacts of hot and cold cups to see the effects of the myriad different assumptions that go into an LCA (see table below).

"Compostable" Serviceware

Summary: *Compostable bioplastic foodware is marketed as "green" but in practice little is composted; almost all is landfilled. Using bioplastic foodware (like PLA) that is landfilled yields no greenhouse gas reduction benefits compared with conventional plastics (like PET).*

First a word about "compostable" food serviceware; most LCAs of food serviceware conducted in the last decade have focused on "compostable" products that mimic conventional plastics, so-called "bioplastics," primarily those made from plant-based materials such as polylactic acid (PLA). We use PLA as a proxy for "compostable" plant-based materials used in food serviceware since it is modeled in EPA's Waste Reduction Model and is most common in North American markets. (Note that conventional paper- and pulp-based foodservice products, like paper napkins, plates and clamshells, are also compostable.)

PLA is marketed as a "green" material because it is made from plants ("bio-based") rather than from petroleum-based chemicals, the burning of which is the primary cause of climate changing greenhouse gas emissions; and because it is designed to be compostable, which in theory returns biological nutrients to the soil (NatureWorks, 2016). The Biodegradable Products Institute (BPI) publishes guidelines that distinguish between "compostable," which can return nutrients to soil, and "biodegradable," which merely breaks materials into smaller and smaller pieces, with no benefit to agriculture and risks to the environment (Responsible Purchasing Network, 2012). On first principles it would seem that composting food scraps together with compostable "food soiled" foodservice items could have considerable greenhouse gas reduction benefits. That's because food scraps that decompose anaerobically in landfills are a major source of methane, a potent greenhouse gas. And food scraps, compared with hard-to-decompose plates and cups, are easier to compost and may generate tip fees. Indeed, looking at food discards together with compostable cutlery, Razza et al. (2009) found significant greenhouse gas benefits.

The reality, however, is that very little of current-generation PLA food serviceware is actually composted in the United States. For one thing, most compost facilities don't accept PLA food serviceware. Seventy percent of the 4,914 facilities nationwide only compost yard trimmings; only about 7% accept food scraps (Platt and Goldstein, 2014). PLA, according to composting industry specialists, generally is not accepted by yard-trimmings-only composters and is accepted by those that compost food scraps on a case-by-case basis (Steve Sherman, interview). This is consistent with data from US Environmental Protection Agency that shows that only 5% of food scraps nationally are recovered for composting; the vast majority of the remaining materials are landfilled (US EPA 2015, p. 62).

A larger problem is that the current generation of compostable food serviceware products do not degrade within the 60 to 90 day cycling times used by commercial composters. This is especially true in California (Steve Sherman, interview). (It should be noted that plastic-coated paper food serviceware can also be problematic in composting operations [EcoCycle and Woods End, 2011]). In practice, partially degraded PLA is screened out and winds up in the landfill, either directly or as "alternative daily cover." An exception could be institutions like universities or prisons that are not under the time constraints of commercial composting operations (Steve Sherman, interview). The University of California at Berkeley does on-site composting and can afford to do long-cycle composting as a project with educational value.

More importantly, using PLA does not reduce greenhouse gas emissions, whether landfilled or composted. Allaway (2016, slides 47, 48, based on Franklin Associates 2009) showed that PLA bottles have higher greenhouse gas emissions than PET bottles when landfilled. This is due to higher emissions in the production (agricultural) phase. It is currently unknown whether PLA decomposes in landfills; if it does, PLA will produce methane, a potent greenhouse gas, which will further increase the climate change impact of PLA. Surprisingly, if PLA undergoes little decomposition in landfills, the global warming potential for landfilled PLA is actually lower than that of composted PLA (Allaway (2016, slides 47, 48). So not only do PLA products cost a premium upfront, the vast majority are landfilled and they have higher life cycle greenhouse gas impacts than conventional plastic disposables.

Studies that compared compostable and reusable food serviceware include Broca 2008; OVAM 2006; Wachter et al. 2013; Vercalsteren et al. 2006; Garrido & del Catillo 2007; Harnato 2012. These studies are mentioned below, but their conclusions must be tempered by the realities and limitations of commercial composting. Other studies compared PLA only with disposable food serviceware made from plastic and paper (Franklin Associates 2011a,b; Madival et al 2009; Razza et al. 2009; van der Harst & Potting 2013).

Hot & Cold Cups

Summary: *Cups are the most studied foodservice product in terms of life cycle greenhouse gas and energy impacts. Results vary widely but improvements in dishwashing energy efficiency suggest that reusable cups have lower impacts than disposable cups in many situations.*

Cups, both hot and cold, are the most frequently studied foodservice products that have been subjected to life cycle assessment (LCA) for energy usage and/or greenhouse gas impacts. This is probably because cups are a highly visible disposable food service item. Woods and Bakshi (2014), citing data from The Freedonia Group, stated that globally over 500 billion disposable cups are sent to landfill every year, with the USA accounting for 37 percent of all foodservice disposables globally in 2010.

The earliest and best-known studies were by Martin Hocking of the University of Victoria, British Columbia, done in the early 1990s. In fact, Hocking's studies (1994a, b, c) played a prominent role in the development of the field of life cycle assessment. His studies were reported in the leading scientific journals, Science and Nature, and have been frequently cited in subsequent decades by LCA practitioners, popular journalists and commercial interests. The polystyrene industry touted Hocking's conclusion that disposable foam cups have lower life cycle energy usage than their reusable counterparts (for an equal amount of product service). For example, Hocking (1994b) found that 1006 foam cups used less life cycle energy than a single ceramic cup reused 1000 times (the "breakeven point"). A major factor was electrical energy dishwashers required for cleaning cups. A Dutch study done for the Benelux Disposables Foundation (TNO, 2007) reported that washing earthenware mugs contributed "between 90 and 100 percent" of their environmental burdens.

Hocking's paper has been widely criticized. A recent study by Woods and Bakshi (2014; see also Merugula & Bakshi, 2014) at Ohio State University obtained quite different results by considering current average cup size (Hocking used an 8 ounce cup whereas today the average is 16 ounces); increases in dishwasher energy and water efficiency; and sensitivity to regional electricity sources. On the latter score, for example, a national

TABLE 1: Break-even points from LCA studies for two types of disposable hot cups compared with ceramic mugs.

		DISPOSABLE										
		Polystyrene Foam (EPS)						Paper				
RESUSABLE	Ceramic	Hocking 1994	Denison 1998	Ziada 2009	Carbon Clear 2012	Woods & Bakshi 2014 Calif 2004AP	Woods & Bakshi 2014 Calif 2013BAT	Hocking 1994	Denison 1998	Starbucks 2000	Ziada 2009	Carbon Clear 2012
		1000	260	127	354	110	70	39	120	70	18	31

shift to natural gas for electricity generation and the prevalence of hydroelectric power on the West Coast results in lower greenhouse gas impacts than those modeled by Hocking. Woods and Bakshi (2014) found that most US consumers live in areas where electricity sources result in lower greenhouse gas emissions for ceramic cups compared with single-use cups.

The point at which the energy or greenhouse gas benefits of reusable cups outweigh disposable cups is called the "break-even point." It is a useful metric for comparing different options. Break-even points for hot cups from LCA studies cover a wide range of values, depending on the age of the study and numerous other factors. For example, comparing foam disposable cups with ceramic mugs, the break-even point was calculated at 1006 cups by Hocking (1994b); 260 cups by Denison (1998a); 127 cups by Ziada (2009); 354 cups by CarbonClear (2012) and 70 cups by Merugula and Bakshi (2014) for best available dishwashing technology operating under California's energy mix. A similar range has been reported for paper cups versus ceramic mugs (Table 1).

Starbucks sells 4 billion disposable cups a year (Minter 2014). In the late 1990s, the company engaged the Environmental Defense Fund (through the Alliance for Environmental Innovation) to investigate increasing the use of reusable cups in the chain's stores. A paper by EDF's lead researcher Richard Dennison (1998a) showed a dramatic advantage for reusables in terms of reduced energy usage. In contrast to Hocking's calculations, ceramic mugs were better (used less energy) than foam cups after 260 uses; and ceramic mugs were better than polyethylene-lined paper cups after 120 uses (Starbucks, 2000). (David Allaway [personal interview] claims that the dishwashing assumptions used by Denison were unrealistically high, biasing the results in favor of single-use; yet despite this, reusables still fared well.) In response to the Alliance for Environmental Innovation work and other pressures, Starbucks set a goal in 2008 of serving 25 percent of all beverages in personal, reusable tumblers by 2015. By 2011, however, the company served just 1.9 percent of its drinks in personal tumblers. Starbucks lowered the 2015 goal to 5 percent (KeepCup, 2012; Minter, 2014). Then they removed the target date: the 2014 Starbucks Global Responsibility Report mentions the 5 percent goal but gives no date (Starbucks, 2015).

Several LCA studies have compared impacts of single-use and reusable cold cups at events. Garrido and Castillo (2007) found reusable cups impractical for large events in Barcelona, Spain, in addition to having high greenhouse gas footprints. Vercalsteren et al. (2010) compared the impacts of disposable, compostable and reusable cold cups at large and small events in Brussels. They found that reusables had lowest combined impacts at small events, but not at large outdoor events. This is because reusable cups at large events had lower return rates (a behavioral issues that could be addressed) and required machine cleaning instead of manual cleaning. In any case, no cup came out best in all impact categories.

Other LCA studies have compared different types of single-use cups but do not include reusables. Franklin Associates (2006b) performed an extensive LCA on single-use cups (2006b) and later updated it to include PLA (2011b). Other studies focusing on compostable PLA cups (but not reusables) include Häkkinen and Vares (2010), and Potting and van der Harst (2014).

Water Service

Summary: *Reuse is far superior to recycling. A detailed study showed that using reusable water containers (glasses, bottles) has far lower global warming potential impacts than recycling single-use water bottles.*

The LCA study that reveals the most dramatic greenhouse gas benefits from source reduction compares tap water in reusable bottles or glasses with water in single-use bottles (Franklin Associates, 2009). Cafeterias distributing bottled water, or contemplating a switch to bottled water from tap water, should be aware of the dramatic greenhouse gas impacts. The 564-page LCA study done by Franklin Associates for the Oregon Department of Environmental Quality quantifies multiple impacts for 48 scenarios comparing single-use disposable water bottles with reusable bottles and table glasses. This and the other Franklin Associates LCA studies reviewed here are particularly valuable because of the extensive and transparent detail provided.

The drinking water systems study found that a reusable water bottle, even using extremely conservative dishwashing assumptions, released 79% percent fewer greenhouse gas emissions over its life cycle than using an equivalent number of PET water bottles once and disposing them. Interestingly, recycling PET bottles only reduces greenhouse gas emissions by 16% compared with waste disposal. Put another way, reuse has a fivefold lower greenhouse gas impact than recycling. And that is a worst-case scenario. Comparing “best case” recycling and “best case” waste prevention (i.e., reuse), the study found that the latter option had a global warming potential impact 98% lower than that of purchasing and recycling water bottles (Allaway, 2009). (Other environmental impacts of reuse, including ecotoxicity, acidification and ozone depletion potentials, were 97.0% to 99.7% lower than the best case recycling scenario.)

Clamshells

Summary: *Two studies comparing life cycle impacts of single-use and reusable clamshells found low reuse usage levels needed for greenhouse emissions savings.*

Several studies compared life cycle impacts of single-use and reusable clamshells. Copeland et al. (2013) compared disposable foam and reusable polypropylene clamshells. They found that reusables only needed to be used 15 times to have a lower greenhouse gas impact compared with disposables; and the energy breakeven point was 30 uses. It’s unclear, however, how they assessed dishwashing impact since it only accounted for 2% of greenhouse gas impacts. Harnato (2013) compared compostable bagasse with reusable polypropylene clamshells in a study for the University of California at Berkeley. She found that the life cycle impacts of reusable polypropylene clamshells were lower after 5.5 uses (the breakeven point). The third study included clamshells in comparisons of compostable and reusable food serviceware in cafeterias at the University of Colorado at Boulder.

Other studies examined only single-use clamshells, comparing compostable and conventional items, excluding reusables. The most detailed is a 2011study by Franklin Associates

(2011b) comparing disposable PLA, polystyrene foam, general-purpose polystyrene, and polyethylene-coated paper clamshells. They found few statistically significant differences in energy impacts. CalRecycle (formerly the California Integrated Waste Management Board) funded a study by Kuczenski et al. (2012) to investigate how extended producer responsibility could be used to reduce greenhouse gas emissions of clamshells. Unfortunately the authors did not consider reuse as a viable option; they made the assumption that recycling is the only practical end-of-life option for greenhouse gas reductions for clamshells.

Plates and Bowls

Summary: *Several studies comparing impacts of single-use versus reusable plates and bowls found modest reuse levels beyond which reusables had lower impacts than single-use items.*

Broca (2008) conducted a life cycle study at Yale University that compared PLA compostable and ceramic reusable plates. She found that ceramic plates had lower overall environmental impact than PLA plates after only 50 uses (the "break-even point"). While this metric incorporated multiple environmental impacts, it was dominated by fossil fuel use which correlates strongly with global warming impact. Wachter et al. (2013) examined food serviceware in cafeterias at the University of Colorado at Boulder. They found that reusable polycarbonate salad bowls had lower global warming potential impacts than single-use compostable bowls after as few as 10 uses. To and Chan (2006) compared single-use paper and ceramic plates and concluded that beyond one year, reusing 400 porcelain plates daily is a better choice in terms of carbon emissions than using 36,000 single-use paper plates per year.

Other studies have examined single-use compostable and disposable plates and bowls without including reusables. Franklin Associates (2011b) performed a detailed life cycle study that showed few significant differences between compostable and disposable plates and bowls.

Flatware

Summary: *The one study reviewed comparing energy impacts of reusable and disposable spoons found dramatic energy savings for reusables.*

Denison (1998) compared the energy footprints of reusable spoons made from stainless steel with disposable spoons made from polystyrene or polypropylene. He compared the amount of energy consumed in production of the spoons and, for the durable spoon, the energy required to wash the spoon 1,000 times. Using conservative assumptions for the reusable product (e.g., rounding up weights) and liberal assumptions for the disposable products (e.g., using lightest-weight products, assuming disposable products used twice), he found that a reusable stainless steel spoon needed only be reused twice to result in energy consumption equal to that of two polystyrene spoons, and reused four times to equal that of four polypropylene spoons.

Several other studies examined energy or greenhouse gas impacts of foodservice cutlery, but they either omitted reusable cutlery (Razza et al. 2009; Jishi et al. 2013) or lacked quantification (Tingley et al. 2011).

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