The Brattle Group

Economic Analysis of SB568's Proposed Polystyrene Ban

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Introduction and Summary

A product ban must be considered in terms of its cost and what it achieves from an environmental and social point of view.[1] Based on our analysis, the costs of banning polystyrene food and beverage containers in California could easily be over $240 million per year and lead to the loss of hundreds of jobs in the state. Costs to already financially strapped public schools, in particular, could exceed $42 million annually. At the same time, the social benefits of the ban are highly uncertain and quite possibly very modest or even nonexistent. According to recent life cycle cost comparisons, substitute products will result in higher energy and water consumption and, depending on the mix of substitutes preferred by consumers, higher greenhouse gas emissions. The impact on litter—a main objective of the ban—also appears to be small or nonexistent. Litter collection costs are unlikely to fall because polystyrene food service items represent a small share of litter and polystyrene replacements will also generate litter. The impact of polystyrene on marine ecosystems is yet unknown and available evidence does not provide justification for significant environmental and economic costs the ban will entail.

The Costs of a Polystyrene Ban Are Likely to be Large

Based on our analysis, the costs of the proposed polystyrene ban are likely to be substantial. The cost to California consumers including households, public school districts, and other government institutions that provide food services could easily reach $240 million annually. Below we present cost estimates for these consumer groups based on the best currently available information. Further analysis would be necessary to provide more precise and detailed costs.

Costs to Households

Household expenditures on food and meals away from home will clearly increase. Based on a recent comparison of posted prices, the price differential between polystyrene food service items (cups, plates, and trays) and alternative items is large. According to distributor price lists, the price for substitute cups, for example, is on average two and a half times the cost of equivalent expanded polystyrene (EPS) cups. As shown in Table 1, based on EPS alternative price differentials and state market volume, California consumer spending could increase by

[1] SB 568 allows school districts and cities and counties to opt out of the ban if they establish recycling programs that they show "based on empirical data" will result in the recycling of at least 60 percent of polystyrene food containers in their jurisdiction. The deadline for school districts to make such a finding is 2017 and the deadline for cities and counties is 2016. The proponents of SB 568 have not shown that it is feasible for cities, counties, and school districts to meet the limited exceptions to the ban. It is reasonable to assume that few jurisdictions will be able to meet SB 568's limited exceptions.

as much as $243 million per year. This cost is only for cups, bowls, plates, and clamshells (also referred to as hingeware). Similar increases are likely for the other EPS food service items replaced by higher cost substitutes. Consequently, the total cost to households could be higher.

Table 1: Total Costs of Expanded Polystyrene Substitution in California

CALIFORNIA NATIONAL MARKET SHARE

US Population	307,000,000	[1]
CA Population	37,000,000	[2]
CA Share of Population	12%	[3]

CALIFORNIA EPS MARKET VOLUME

Item	National Volume	California Volume
	[4]	[5]
Cups	25,503,000,000	3,060,360,000
Bowls	2,637,000,000	316,440,000
Hingeware	10,817,000,000	1,298,040,000
Plates	2,637,000,000	316,440,000

PRICE COMPARISON

Product	Cost (per 1000)	Cost of Substitution	Cost of California Substitution
	[6]	[7]	[8]
Dart Flush Fill White Foam Cup - 16 oz.	$28.49		
Solo White Paper Hot Cup - 16 oz.	$73.99	$45.50	$139,246,380
Dart White Foam Bowl - 12 oz.	$15.18		
Green Wave Biodegradable Bowl - 12 oz.	$49.99	$34.81	$11,015,276
Dart Perforated Hinged Lid Take Out Container - 9x9x3	$66.80		
Clear Hinged Lid Plastic Container - 9x9x3	$126.75	$59.95	$77,817,498
Dart 3 Compartment White Foam Plate - 9"	$26.10		
Solo Medium Weight Paper Plate - 9"	$74.98	$48.88	$15,467,587
Total Estimated Annual Cost of EPS Substitution in CA			**$243,546,742**

Notes:
[1]: U.S. Census Bureau
[2]: U.S. Census Bureau
[3]: [3] / [2]
[4]: 2010 Market Research Study on Foodservice Packaging Products, Foodservice Packaging Institute. Assumes evenly split allocation of market volume for bowls, plates, and platters.
[5]: [3] x [4]
[6]: Price of lowest cost polystyrene and alternative products obtained from www.webstaurantstore.com
[7]: Difference between alternative and polystyrene products from [6]
[8]: [7] x ([5] / 1000)

Cost of Polystyrene Ban on California's Public School Districts

School districts and other public institutions that provide food services using polystyrene products would experience substantial cost increases. While it is difficult to calculate these costs precisely, we do have information on the number of polystyrene trays sold to California public schools and data for some public school districts. We do not, however, have data on the number of other food service items including cups. There are also differences in the reported costs for polystyrene product replacements. Below we present a lower and an upper bound cost estimate reflecting these uncertainties.

Conservative Lower Bound Cost

Based on a Plastic Food Packaging Group estimate and data from a large California-based distributor, 170 million polystyrene trays are sold to California public schools annually. Since some alternatives to polystyrene trays may cost as little as $0.04 more than polystyrene trays, total annual costs of the ban would be a minimum of $6.8 million. This is conservative because it assumes every polystyrene cup would be replaced by the least-cost alternative and does not include other polystyrene food service items that schools sometimes use including cups.

The following table summarizes the costs of the ban to selected California school districts that currently rely on polystyrene trays.

Table 2: Cost of Substitution in Select Districts Currently Using Polystyrene Trays

School District	Annual Cases Ordered	Total Cost for Polystyrene Trays ($16 per case)	Total Cost for Alternative Trays ($35 per case)	Annual Cost of Substitution of Polystyrene Trays
	[1]	[2]	[3]	[4]
El Segundo	160	$2,560	$5,600	$3,040
Torrance	1,500	$24,000	$52,500	$28,500
Manhattan Beach	700	$11,200	$24,500	$13,300
Chula Vista	6,000	$96,000	$210,000	$114,000
Culver City	600	$9,600	$21,000	$11,400
Los Alamitos	600	$9,600	$21,000	$11,400
Monrovia	700	$11,200	$24,500	$13,300
Ontario	2,000	$32,000	$70,000	$38,000
Pasadena	600	$9,600	$21,000	$11,400
Santee	1,000	$16,000	$35,000	$19,000
South Bay	2,600	$41,600	$91,000	$49,400
Valley Center	300	$4,800	$10,500	$5,700

Notes
[1]: Data provided by P&R Paper Supply.
[2]: Ibid.
[3]: Ibid. Average cost of bagasse and molded fiber alternatives.
[4]: [3] - [2]

Upper Bound Cost

Accounting for higher cost per tray by using an incremental cost of $0.20 per tray, the ban will cost $34.0 million annually. This cost was reported by the Long Beach School District and was confirmed in a recent phone call with the District buyer. In addition, adding other food service items (cups) with observed cost differences for alternatives of $0.05 per unit would add $8.5 million annually. Consequently, total costs of the ban could easily be six times the lower bound ($42.5 million v. $6.8 million).

Cost of Polystyrene Ban on California's Public College System

California's college system (University of California, California State University, and community colleges) would also face rising costs in the face of a polystyrene ban. Using a recent procurement request distributed by UC Riverside, the total demand for disposable food service items in the California college system can be approximated. While some campuses have already excluded polystyrene products, they do so at a cost. Using the price differential between EPS products and their lowest priced alternatives, the total cost savings of maintaining or switching to EPS products is estimated at almost $8 million annually, as depicted in Table 3 on the following page.

Cost of Polystyrene Ban on California's Health Care Industry

Using information on the number of polystyrene cups disposed by the Gould Medical Foundation, a health care organization administering to 631,000 patient visits per year, we are able to estimate the average number of polystyrene cups in use relative to patient visits. By extrapolating this calculation to account for all patient visits within California each year, we can generate an estimate of the number of polystyrene cups used annually by California's health care industry. Comparing this total to the average cost of substitution calculated in Table 1, we find an estimated statewide cost to health care of around $3 million assuming substitution of all polystyrene cups. This calculation is depicted in Table 4 below. This is once again the cost of substitution for a single food service item, and total costs would likely be significantly higher.

Table 3: Expanded Polystyrene Cost Savings to California's Public College System

CALIFORNIA COLLEGE ENROLLMENT

College	Enrollment	
UC Riverside	20,746	[1]
CA Community Colleges	2,700,000	[2]
California State University	400,000	[3]
University of California	219,000	[4]
All California Colleges	**3,319,000**	[5]

CALIFORNIA COLLEGE ORDER VOLUME

Item	UC Riverside Total Order	Number per Student	California Colleges Total
	[6]	[7]	[8]
Cups	315,000	15.19	50,415,610
Bowls	80,000	3.86	12,811,340
Hingeware	50,000	2.39	7,932,410
Plates	360,000	17.43	57,850,170

PRICE COMPARISON

Product	Cost per 1000	Cost of Substitution	Cost to State Colleges
	[9]	[10]	[11]
Average 16 oz. Polystyrene Cup (See Table 1)	$41.76		
Average 16 oz. Alternative Cup (See Table 1)	$120.43	$78.67	$3,966,196
Dart White Foam Bowl - 12 oz.	$15.18		
Green Wave Biodegradable Bowl - 12 oz.	$49.99	$34.81	$445,963
Dart Perforated Hinged Lid Take Out Container - 9x9x3	$66.80		
Clear Hinged Lid Plastic Container - 9x9x3	$126.75	$59.95	$475,548
Dart 3 Compartment White Foam Plate - 9"	$26.10		
Solo Medium Weight Paper Plate - 9"	$74.98	$48.88	$2,827,716
Total Polystyrene Cost Savings to California Colleges			**$7,715,423**

Notes:
[1]: UC Riverside Facts, http://www.ucr.edu/about/facts.html
[2]: Chancellor's Office, California Community College Datamart
[3]: California State University Chancellor's Office
[4]: University of California Office of the President, Statistical Summary and Data on UC Students, Faculty, and Staff, Fall 20
[5]: [2] + [3] + [4]
[6]: UCR Request for Proposal #RFP 330-16 For Disposable Paper, Plastic, and Foam products
[7]: [6] / [1]
[8]: [7] x [5]
[9]: Price of lowest cost polystyrene and alternative products obtained from www.webstaurantstore.com
[10] Difference between alternative and polystyrene products from [9]
[11] [10] * ([5] / 1000)

Table 4: Costs to California Health Care Industry from Polystyrene Cup Substitution

Gould Medical Foundation Polystyrene Cups Used per Year	300,000	[1]
Gould Medical Foundation Patient Visits	631,000	[2]
Polystyrene Cups Used per Patient Visit	0.475	[3]
Total Patient Visits in US	1,189,619,000	[4]
California Share of US Population	12%	[5]
Estimated California Patient Visits	142,754,280	[6]
Total Polystyrene Cups used in CA Health Care Industry	67,870,498	[7]
Average Cost of Polystyrene Cup Substitution	$0.0455	[8]
Statewide Cost of Polystyrene Cup Substitution in Health Care Industry	**$3,088,108**	[9]

Notes:
[1]: Sutter Gould Medical Foundation, "Facts at a Glance", 2006
<http://www.sutterhealth.org/about/snapshots/gould2.pdf>
[2]: CalRecycle, "Waste Reduction Awards Program Winners"
<http://www.calrecycle.ca.gov/WRAP/search.asp?VW=APP&BIZID=5848&YEAR=2010&CNTY=>
[3]: [1] / [2]
[4]: US Department of Health and Human Services, *Health, United States, 2010*. Table 91.
<http://www.cdc.gov/nchs/data/hus/hus10.pdf>
[5]: U.S. Census Bureau
[6]: [4] x [5]
[7]: [3] x [6]
[8]: See Table 1
[9]: [7] x [8]

The Environmental Benefits of a Polystyrene Ban Are Uncertain and Possibly Negative

Measuring the benefits of a ban requires special attention to the available substitutes. The substitutes can be no improvement over the banned product with respect to the intended objective of the ban. In fact, based on several life-cycle assessments, polystyrene food service products consume less energy and water and generate less greenhouse gases in production and transport than substitutes such as wax coated paper and polyethylene.[2] Consequently a ban is likely to substantially increase energy and water consumption and possibly generate more greenhouse gases.

Impacts on Energy and Water Consumption

For example, if 16 oz polystyrene cups were replaced by any one of several substitutes identified in a recent lifecycle cost analysis, the resulting additional energy consumption would be equivalent to the additional energy consumption of between 3,130 and 12,500

[2] We reviewed Franklin Associates (2011) and Herrera Environmental Consultants (2008).

homes for 16oz hot cups, and 2,700 to 39,000 homes for 32oz cold cups.[3] This is shown in Figure 1.[4]

Substitutions could also lead to increased water consumption by the equivalent of 3,700 to 9,300 average US households for 16oz hot cups and 2,200 to 41,000 households for 32oz cold cups.[5] This is displayed in Figure 2.

Impacts on Greenhouse Gas Emissions

Greenhouse gas emissions from the same substitutions could decrease by the equivalent of 27,000 autos or increase by the equivalent of 21,000 autos for 16oz hot cups, and decrease by 50,000 autos or increase by 64,000 autos for 32oz cold cups. [6] This is portrayed in Figure 3. The result depends on which polystyrene substitutes consumers prefer and what assumptions are made about whether substitute products are fully compostable. For example, if consumers use two paper cups as a substitute for one polystyrene cup for hot beverages, which is common because polystyrene cups are excellent insulators and paper cups are not, the paper cup substitutes will emit more greenhouse gases.

If one assumes that substitute products are fully compostable, then polystyrene products have lower greenhouse gas emissions than the substitute products. If one assumes that the substitute products are not compostable, then the substitute products may have lower greenhouse gas emissions; however, this negates one of the asserted advantages of these products (i.e., that they are compostable). The measurement of greenhouse gas emissions highlights how uncertain the measurement of the benefits of a polystyrene ban can be.

In addition, the greenhouse gas analysis assumes that neither polystyrene food containers nor their substitutes are recycled. This is a conservative assumption, because polystyrene food containers are readily recyclable and their substitutes may not be. For example, cups that combine paper and plastic are not generally recyclable.

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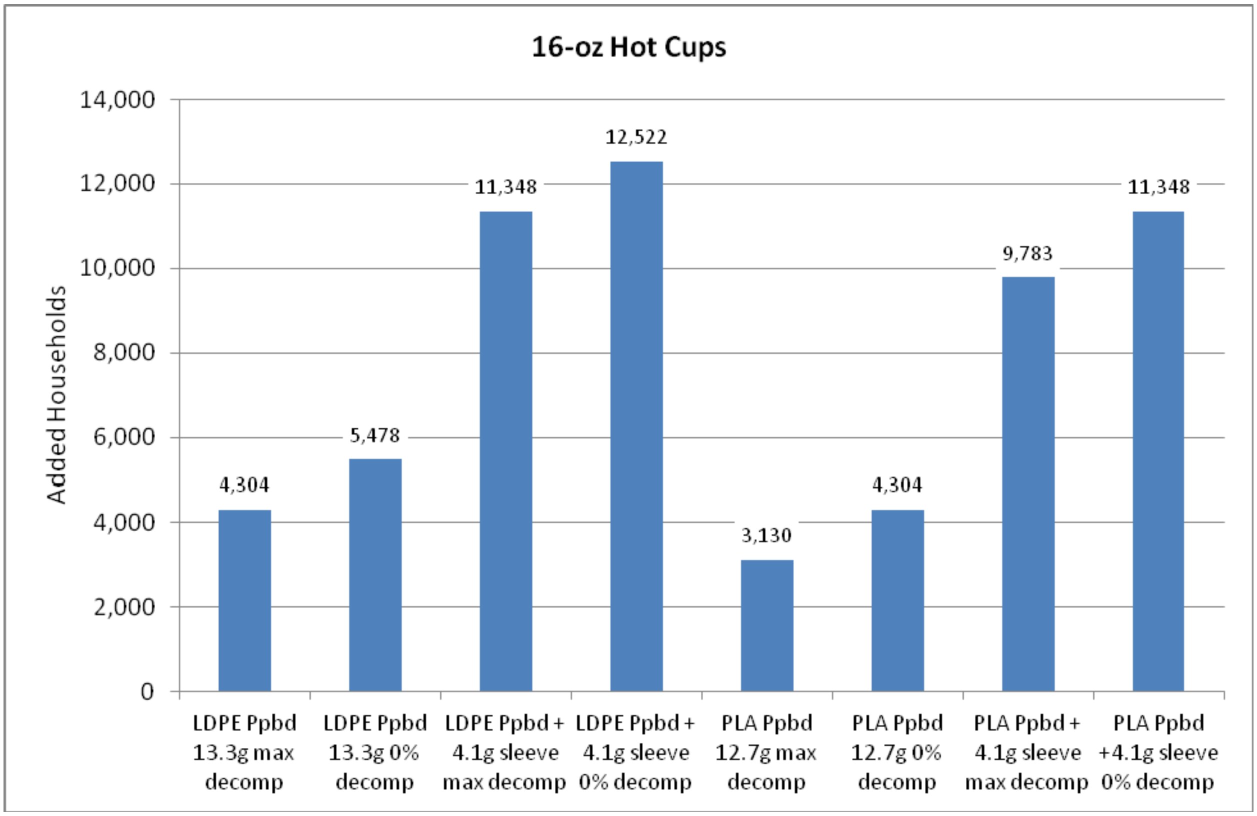
[3] These calculations rely on Franklin Associates (2011). Assumes Average household energy consumption is 77 million BTU. See appendix table A-1.

[4] The lifecycle cost analysis did not consider that unlike polystyrene cups, which contain heat effectively, other cups do a poor job resulting in many consumers using double cups. The study did account for the addition of paper sleeves to contain heat in some non-polystyrene cups.

[5] These calculations rely on Franklin Associates (2011). Assumes average household water consumption is 114,464 gallons. See appendix table A-2.

[6] These calculations rely on Franklin Associates (2011). Assumes average auto fuel emissions used are 7064 lbs CO2 equivalent. See appendix table A-3.

Figure 1: Added Energy Consumption in Average Household Equivalents from Substitution of EPS 16-oz Hot Cups and 32-oz Cold Cups



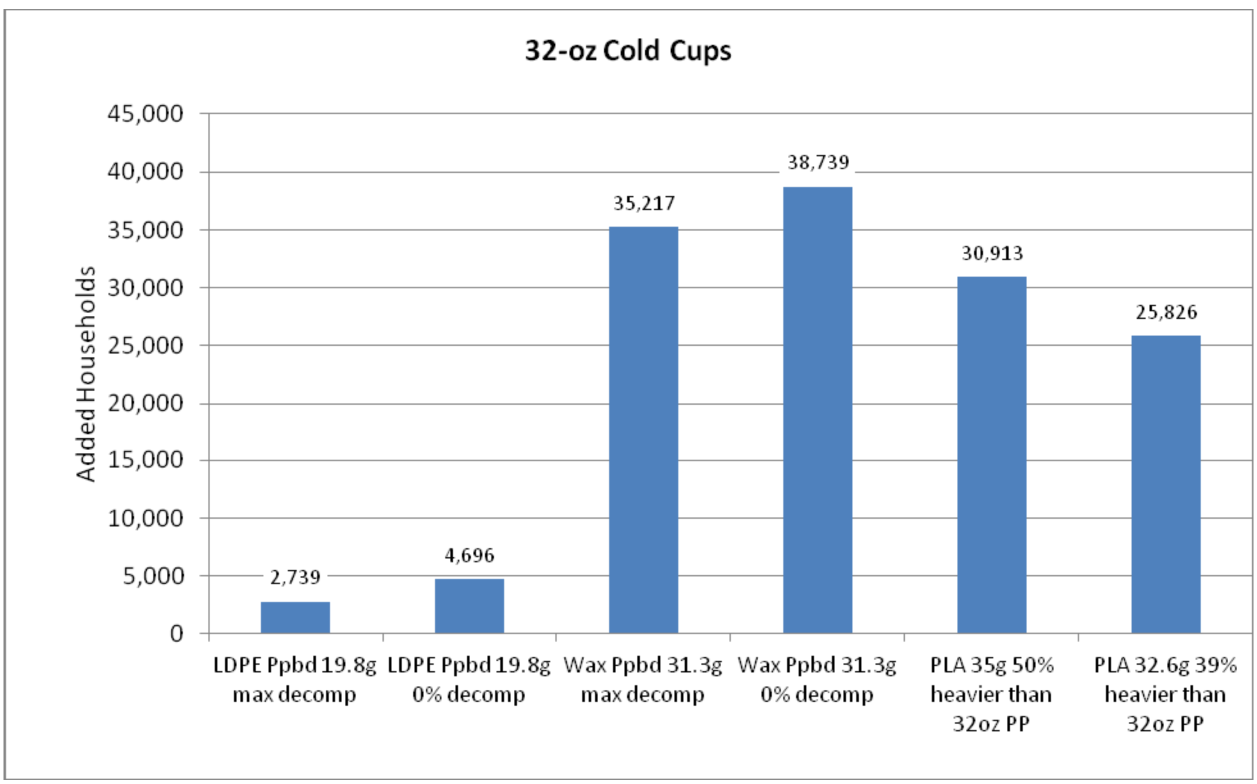
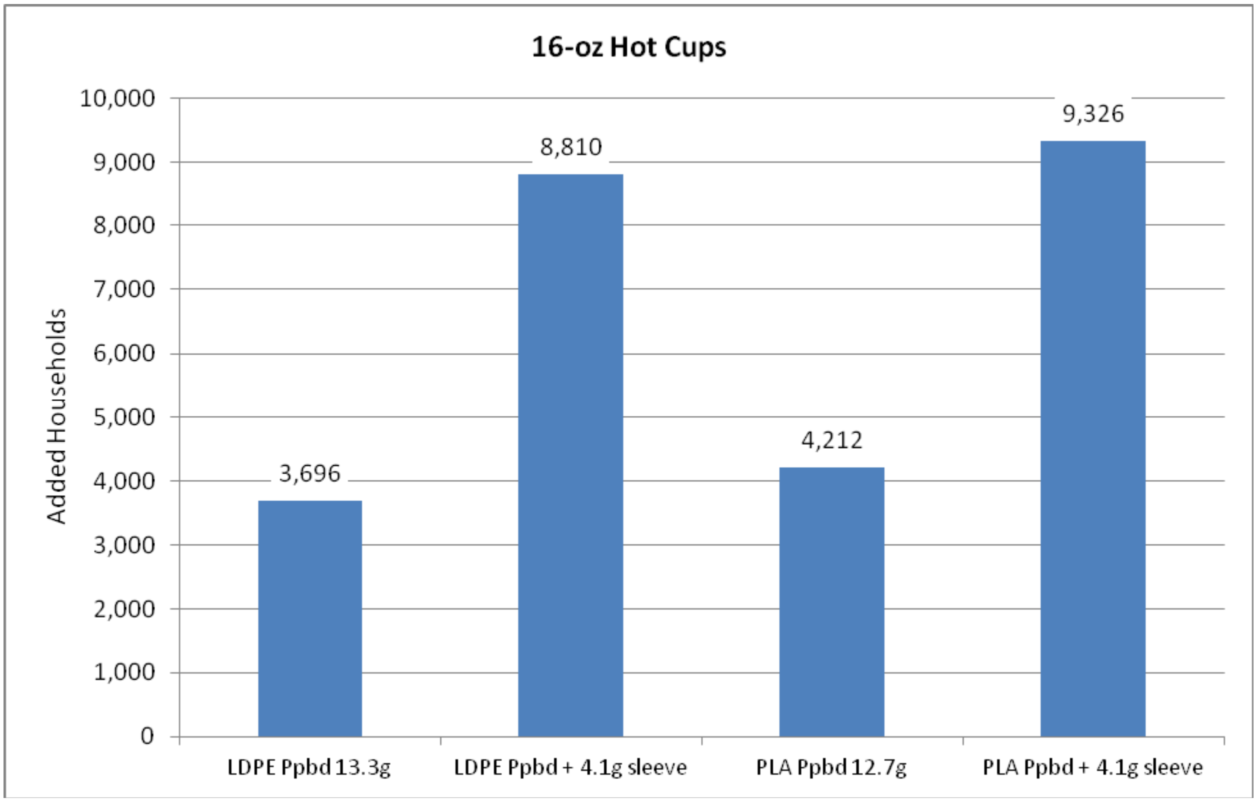


Figure 2: Added Water Consumption in Average Annual Household Use Equivalents from Substitution of EPS 16-oz Hot Cups and 32-oz Cold Cups



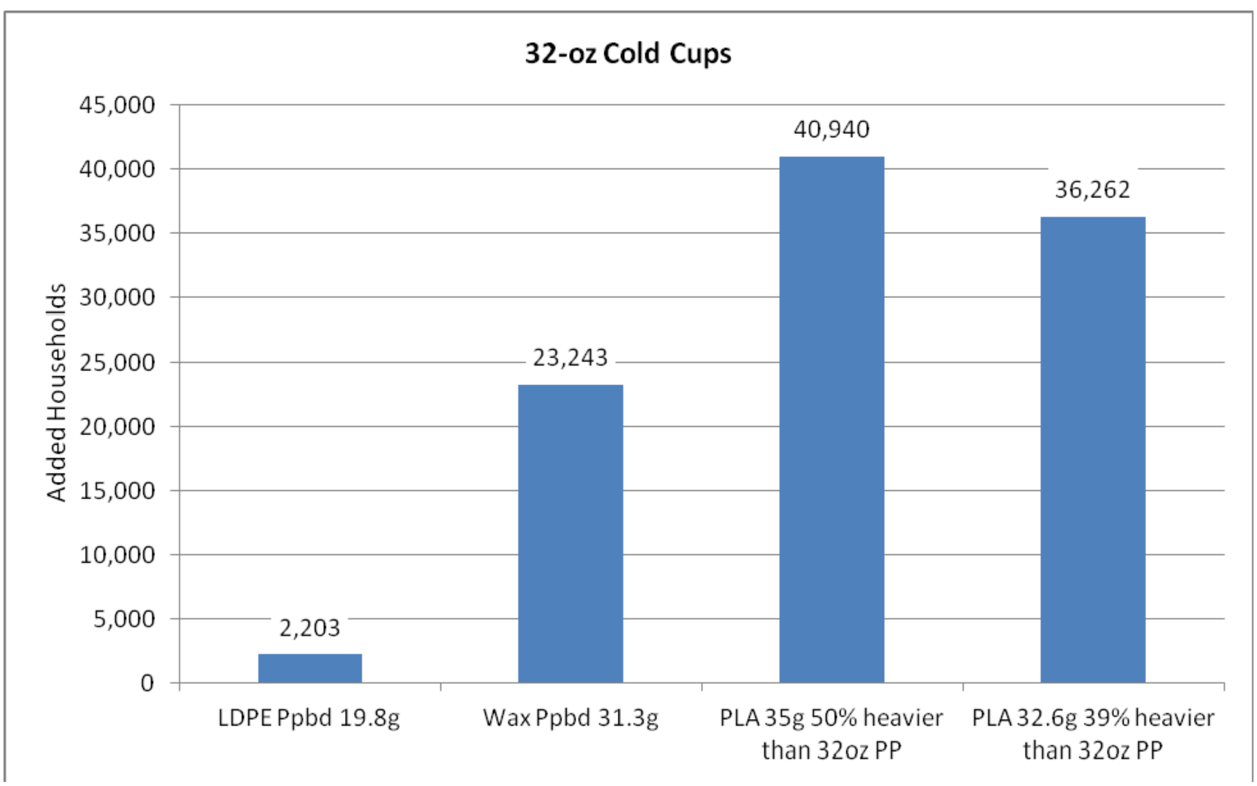
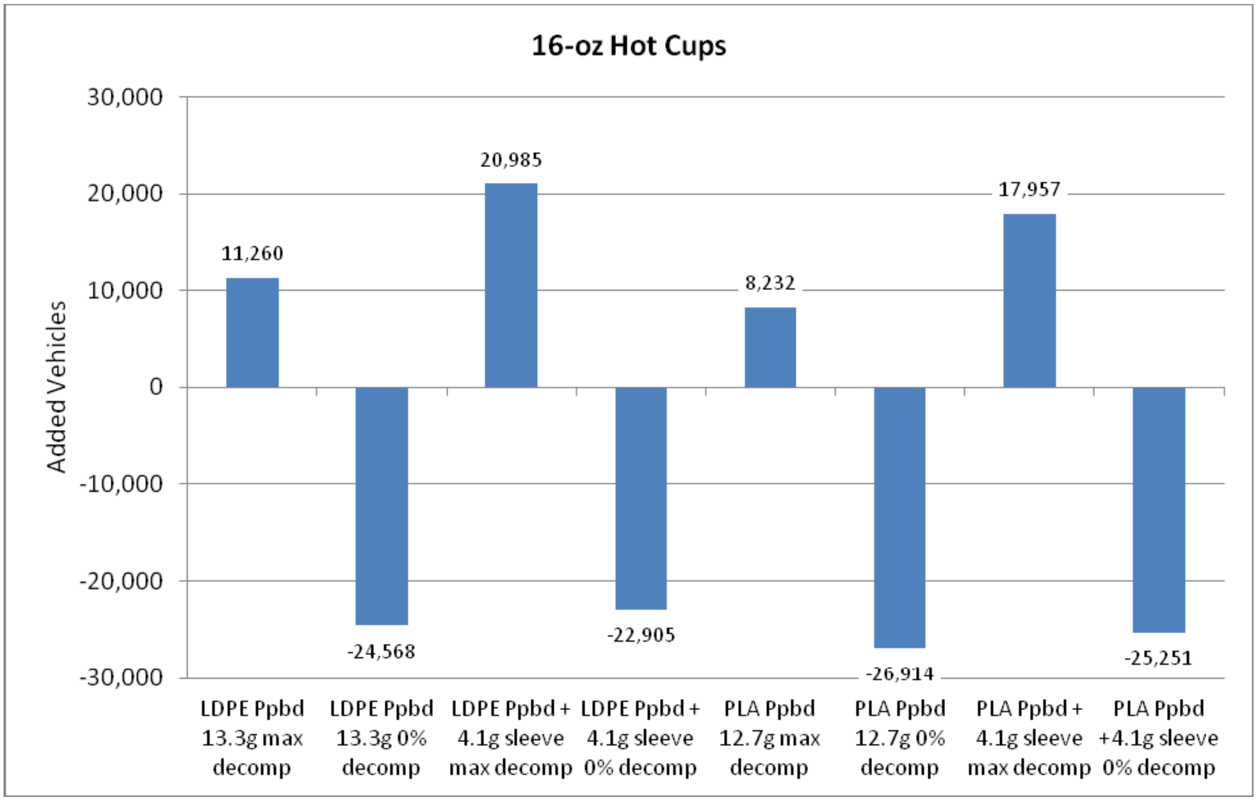
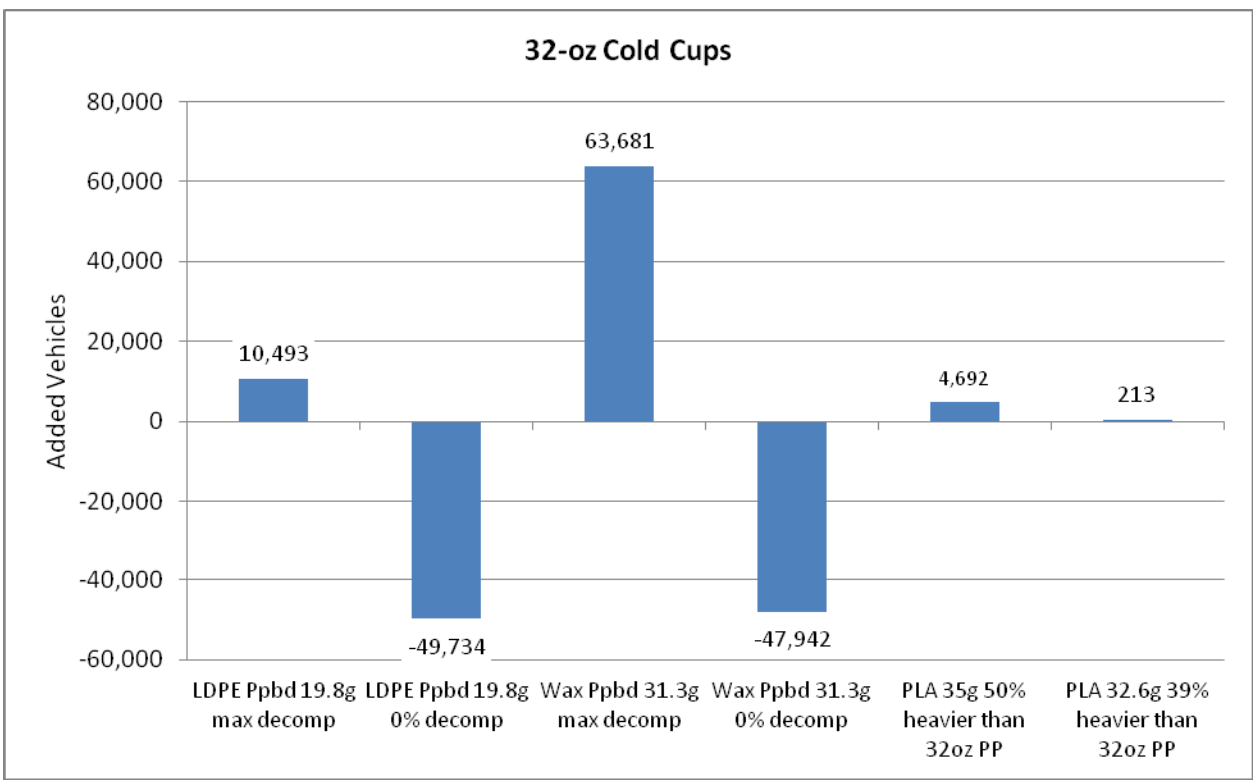


Figure 3: Added GHG Emissions in Average Vehicle Equivalents from Substitution of EPS 16-oz Hot Cups and 32-oz Cold Cups





Impact on Marine Environments

Research has not shown any clear link between polystyrene and damage to marine life (birds, fish, and plants).[7] The National Oceanic and Atmospheric Administration (NOAA) observes that the source of the small plastics (microplastics) that are of greatest concern is unknown. Some comes from primary sources (plastics in a small state at the time of discharge) while other small plastic comes from the breakdown of larger plastic sources including litter and other marine debris.[8] NOAA further notes the "paucity of data" on the impacts of small plastic debris on the marine environment.[9] NOAA observes that "…overall the impact on entire seabird populations is either unknown or not considered large enough to warrant further investigation at this time."[10] NOAA concludes that:

> Altogether, the science suggests that microplastics deserve further scrutiny in the laboratory and the field…. Only then will it be possible for the best science to inform management decisions for the remediation and prevention of microplastic pollution in the marine environment.[11]

A recent study found that less than 10 percent of mesopelagic fish samples in the North Pacific Gyre had ingested plastics from all sources.[12] While the study authors estimated the potential tons of plastics ingested, they recognized the uncertainties regarding the impacts on fish populations. Their finding also indicates that 90 percent of the mesopelagic fish populations were not found to ingest plastics despite being in a region with higher than normal plastics concentrations.

Not only are the sources and impacts of marine microplastics unknown, the amount of plastic debris from polystyrene is likely to be small. A recent study for Keep American Beautiful (KAB), for example, found that expanded polystyrene materials other than food service items accounted for a very modest share of the litter items found at storm drains nationwide. [13] This

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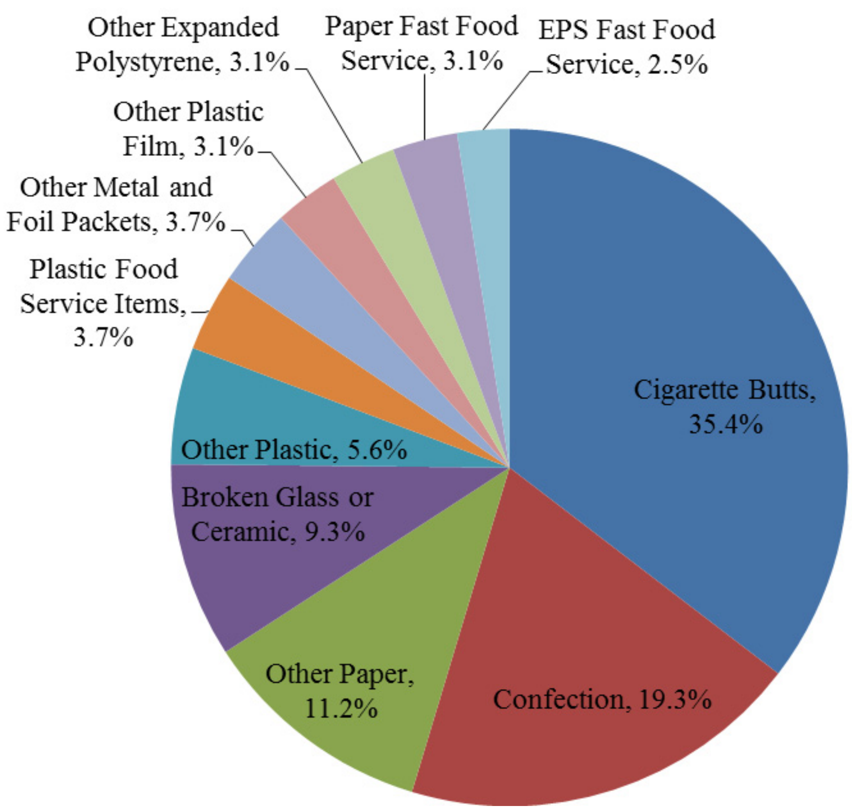
[7] Courtney Arthur, Joel Baker, and Holly Bamford, editors, "Proceedings of the International Research Workshop on the Occurance, Effects, and Fate of Mircroplastic Marine Debris," Department of Commerce, National Oceanic and Atmospheric Administration, Technical Memorandum NOS-OR&R-30, January, 2009.
[8] Arthur, et. al. p. 5 of the Executive Summary.
[9] Arthur, et. al. p. 2 of the Executive Summary.
[10]Arthur, et. al. p. 2 of the Executive Summary.
[11] Arthur, et.al. p 5 of the Executive Summary.
[12] Peter Davison and Rebecca Asch, "Plastic ingestion by mesopelagic fishes in the North Pacific Subtropical Gyre," Marine Ecology Progress Series, Vol. 432: 172-180, 2011. Mesopelagic fish primarily occupy lower ocean depths but rise to surface waters at night to feed.
[13] Mid Atlantic Solid Waste Consultants, "2009 National Visible Litter Survey" Prepared for Keep America Beautiful, Final Report, September 18, 2009,Figure 3-6, pg.3-30.

is shown in Figure 4. Expanded polystyrene food service items accounted for only 2.5% of litter collected in storm drains and did not make the top ten litter types reported by KAB.[14]

In addition, substitute products for polystyrene are not clearly less of a problem to marine life than some of the available substitutes that contain other plastics. Given the significant environmental and economic costs of a ban on polystyrene food containers, the unknown, speculative potential benefits to the marine environment cannot justify a ban on polystyrene food containers.

Figure 4: Share of Top 11 Most Common Litter Items at US Storm Drains



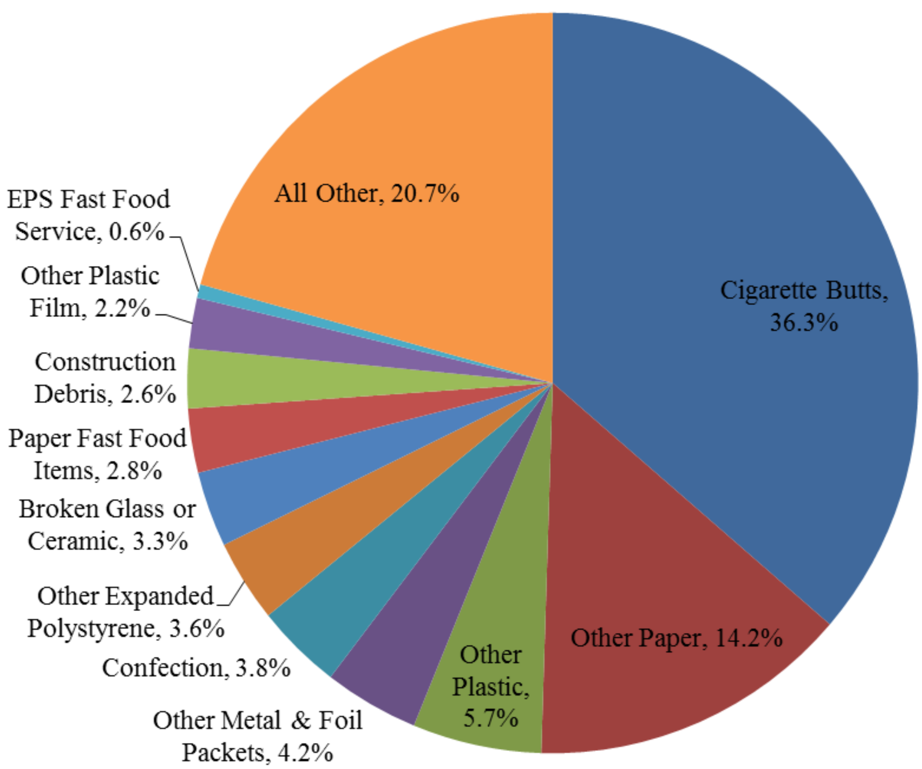
Impact on Litter Reduction

It is also not clear that banning polystyrene food service items will reduce litter – a prime objective of the ban. What is more likely to happen is a change in the composition of litter. We have found no evidence that litter control costs have declined in cities where polystyrene items have been banned. It is also worth noting that polystyrene does not appear to be a

[14] Other studies have found polystyrene food items comprising a larger fraction of litter found at storm drains. The Surfrider Foundation, for example, recently studied litter at two storm drains and found that polystyrene food items accounted for 20 percent of litter. Since litter composition will be affected by surrounding land uses, there is likely to be substantial variation across sites. The KAB study is based on a wider sampling of storm drains.

major litter component. Consequently, banning polystyrene will not reduce the cost of litter clean-up substantially. A 2007 San Francisco survey conducted before the City implemented a ban on polystyrene service items, for example, found that polystyrene cups accounted for less than 2% of observed litter.[15] The Keep American Beautiful litter study referenced earlier determined that *other* expanded polystyrene was among the top ten sources of roadway, however, it accounted for only 3.6% of the litter items found on U.S. roadways.[16] See Figure 5. Again polystyrene food service items were not among the top ten sources of litter. Based on the KAB survey, polystyrene food items represented only 0.6% of roadway litter ranking it 21st.[17]

Figure 5: Relative Share of Litter Items on U.S. Roadways



15 "The City of San Francisco Streets Litter Audit." Prepared for the City and County of San Francisco Department of Environment by HDR, Brown Vence & Associates, and MGM Management, June 2007. P. 27. The survey was completed in April 2007, the ban went into effect on June 1, 2007.

16 Midatlantic Solid Waste Consultants, 2009 National Visible Litter Survey and Litter Cost Study, prepared for Keep America Beautiful, Final Report, September 18, 2009, pp 3-2 to 3-2, Figure 3-3. The study defines other expanded polystyrene as non-food packaging and finished products with an SPI 6 designation. (see Appendix A, A-2).

17 Personal communications with a KAB study author.

Impact on Litter Abatement Costs

The KAB study also investigated the cost of litter control via a survey of local, county and state agencies. KAB's consultants used the survey to estimate per capita litter control costs for each level of government. Using this data, we can estimate the cost of litter control in California and allocate the cost shares attributable to polystyrene. As shown in Table 5, annual costs across all three government levels in California total about $151 million according to the survey. Thus, eliminating polystyrene food items, assuming that there is no litter from the substitute items chosen, would reduce annual litter abatement and removal costs by no more than $0.9 million.[18] Since many polystyrene substitutes such as paper cups will also produce litter, the savings would be much lower and perhaps nonexistent.

The KAB study also found that litter levels have fallen dramatically since the late 1960s. Much of this reduction can be attributed to better education, more waste receptacles, more street cleaning, better landfill management, and container deposit programs.

Table 5: Total California Litter Cleanup Costs

State Costs	$44,332,208
County Costs	$20,381,116
City Costs	$86,674,005
Total Litter Cleanup Costs	**$151,387,329**

Sources:
2010 U.S. Census
Mid Atlantic Solid Waste Consultants, "2009 National Visible Litter Survey".
Prepared for Keep America Beautiful, Final Report, September 18, 2009, p. 91-93.

There are other alternatives to the polystyrene ban to reduce litter as well. Los Angeles has elected to encourage polystyrene recycling. Other California cities have also rejected polystyrene bans, and presumably are pursuing other approaches.

Since other California cities including San Francisco, Oakland, and Berkeley have introduced bans, there is a great opportunity to conduct an important social experiment. Different approaches to litter reduction (and marine protection) can be compared regarding litter volume, composition, and cost and effectiveness provided enough time has elapsed to collect the necessary data. At the same time, research regarding the impacts of polystyrene and other plastics on the marine environment is likely to progress.

[18] This figure is calculated as 0.006 x $151 million, which is the share of polystyrene food containers of all litter (0.6%) multiplied by the total cost of litter abatement.

Conclusion

The available evidence does not support the introduction of a polystyrene ban. The costs are likely to be large without clear corresponding benefits. This conclusion is consistent with a previous study conducted by the Integrated Solid Waste Management Board for the State Legislature.[19] The Board did not find a polystyrene ban attractive. Instead the Board recommended increasing educational efforts to discourage litter, issuing litter tickets, and conducting further research regarding effective litter management approaches. In fact, the different approaches to litter reduction and polystyrene taken by various California cities and counties provide the opportunity to study the costs and benefits of multiple approaches to efficiently manage polystyrene and other waste materials including bans and incentives for recycling.

[19] Integrated Solid Waste Management Board,"Use and Disposal of Polystyrene in California, A Report to the California Legislature," December 2004, pp5-6.

APPENDICES

Table A-1: Energy Use Comparison for Polystyrene Foodservice Product Alternatives

Product	Million BTU	Net vs. Polystyrene	Net Difference as % of Annual Average Household Consumption	Converted Products Required to Consume Energy of 1 Additional Household	Added Households of Energy Consumption from Substitution of EPS
	[1]	[2]	[3]	[4]	[5]
Energy Use for 16-oz Hot Cups (10,000 average weight cups)					
EPS 4.7g	5.4				
LDPE Ppbd 13.3g max decomp	6.5	1.1	1.43%	700,000	4,304
LDPE Ppbd 13.3g 0% decomp	6.8	1.4	1.82%	550,000	5,478
LDPE Ppbd + 4.1g sleeve max decomp	8.3	2.9	3.77%	265,517	11,348
LDPE Ppbd + 4.1g sleeve 0% decomp	8.6	3.2	4.16%	240,625	12,522
PLA Ppbd 12.7g max decomp	6.2	0.8	1.04%	962,500	3,130
PLA Ppbd 12.7g 0% decomp	6.5	1.1	1.43%	700,000	4,304
PLA Ppbd + 4.1g sleeve max decomp	7.9	2.5	3.25%	308,000	9,783
PLA Ppbd +4.1g sleeve 0% decomp	8.3	2.9	3.77%	265,517	11,348
Energy Use for 32-oz Cold Cups (10,000 average weight cups)					
EPS 8.8g	9.6				
LDPE Ppbd 19.8g max decomp	10.3	0.7	0.91%	1,100,000	2,739
LDPE Ppbd 19.8g 0% decomp	10.8	1.2	1.56%	641,667	4,696
Wax Ppbd 31.3g max decomp	18.6	9	11.69%	85,556	35,217
Wax Ppbd 31.3g 0% decomp	19.5	9.9	12.86%	77,778	38,739
PLA 35g 50% heavier than 32oz PP	17.5	7.9	10.26%	97,468	30,913
PLA 32.6g 39% heavier than 32oz PP	16.2	6.6	8.57%	116,667	25,826
Energy Use for 9-inch Plates (10,000 average weight plates)					
Heavy-Duty Plates					
GPPS 10.8g	8.4				
LDPE Ppbd 18.4g max decomp	10.3	1.9	2.47%	405,263	
LDPE Ppbd 18.4g 0% decomp	9.7	1.3	1.69%	592,308	
Mold Pulp 16.6g max decomp	10.9	2.5	3.25%	308,000	
Mold Pulp 16.6g 0% decomp	11.3	2.9	3.77%	265,517	
PLA 20.7g	10.4	2	2.60%	385,000	
Lightweight Plates					
2009 GPPS 4.7g	3.6				
2009 LDPE Ppbd 12.1g max decomp	6.1	2.5	3.25%	308,000	
Energy Use for Sandwich-size Clamshells (10,000 average weight clamshells)					
GPPS 4.8g	3.8				
Fluted Ppbd 10.2g max decomp	5.8	2	2.60%	385,000	
Fluted Ppbd 10.2g 0% decomp	6	2.2	2.86%	350,000	
PLA 23.3g	14.4	10.6	13.77%	72,642	

Notes:

Net expended energy = total energy requirements - energy recovery - energy content of landfilled material

[1]: Franklin Associates, "Life Cycle Inventory of Foam Polystyrene, Paper-Based, and PLA Foodservice Products", 4 February 2011.

[2]: [1] - Equivalent Polystyrene Product Energy Use in [1]

[3]: Assumes 2005 Western census region annual household energy consumption. <http://www.eia.gov/totalenergy/data/annual/txt/ptb0204.html>

[4]: 1 / [3] * 10,000

[5]: Assumes 3 billion cups disposed of in CA per year. See Table 1.

Table A-2: Water Use Comparison for Polystyrene Foodservice Product Alternatives

Product	Gallons	Net vs. Polystyrene	Net Difference as % of Annual Average Household Consumption	Converted Products Required to Consume Water of 1 Additional Household	Added Households of Water Consumption from Substitution of EPS
	[1]	[2]	[3]	[4]	[5]
Water Use for 16-oz Hot Cups (gallons per 10,000 average weight cups)					
EPS 4.7g	4748				
LDPE Ppbd 13.3g	6152	1404	1.23%	815,271	3,696
LDPE Ppbd + 4.1g sleeve	8095	3347	2.92%	341,990	8,810
PLA Ppbd 12.7g	6348	1600	1.40%	715,400	4,212
PLA Ppbd + 4.1g sleeve	8291	3543	3.10%	323,071	9,326
Water Use for 32-oz Cold Cups (gallons per 10,000 average weight cups)					
EPS 8.8g	8441				
LDPE Ppbd 19.8g	9278	837	0.73%	1,367,551	2,203
Wax Ppbd 31.3g	17271	8830	7.71%	129,631	23,243
PLA 35g 50% heavier than 32oz PP	23994	15553	13.59%	73,596	40,940
PLA 32.6g 39% heavier than 32oz PP	22217	13776	12.04%	83,089	36,262
Water Use for 9-inch Plates (gallons per 10,000 average weight plates)					
Heavy-Duty Plates					
GPPS 10.8g	7466				
LDPE Ppbd 18.4g	8898	1432	1.25%	799,330	
Mold Pulp 16.6g	9017	1551	1.36%	738,001	
PLA 20.7g	14208	6742	5.89%	169,778	
Water Use Emissions for Sandwich-size Clamshells (gallons per 10,000 average weight clamshells)					
GPPS 4.8g	3873				
Fluted Ppbd 10.2g	4951	1078	0.94%	1,061,818	
PLA 23.3g	15996	12123	10.59%	94,419	

Notes:

[1]: Franklin Associates, "Life Cycle Inventory of Foam Polystyrene, Paper-Based, and PLA Foodservice Products", 4 February 2011.

[2]: [1] - Equivalent Polystyrene Product Water Use in [1]

[3]: Assumes average domestic per capita water use at average household size of 3.2 individuals, equal to 114,464 gallons per year.
<http://ga.water.usgs.gov/edu/wateruse/pdf/wudomestic-2005.pdf>

[4]: 1 / [3] * 10,000

[5]: Assumes 3 billion cups disposed of in CA per year. See Table 1.

Table A-3: Greenhouse Gas Emissions Comparison for Polystyrene Foodservice Product Alternatives

Product	Pounds CO2 Equivalents	Net vs. Polystyrene	Net Difference as % of Average Annual Vehicle Emissions	Converted Products Required to Generate Emissions of 1 Additional Vehicle	Added Average Vehicle Emissions Added from Substitution of EPS
	[1]	[2]	[3]	[4]	[5]
Greenhouse Gas Emissions for 16-oz Hot Cups (lb CO2 eq per 10,000 average weight cups)					
EPS 4.7g	723				
LDPE Ppbd 13.3g max decomp	987	264	3.74%	267,576	11,260
LDPE Ppbd 13.3g 0% decomp	147	-576	-8.15%	-122,639	-24,568
LDPE Ppbd + 4.1g sleeve max decomp	1215	492	6.96%	143,577	20,985
LDPE Ppbd + 4.1g sleeve 0% decomp	186	-537	-7.60%	-131,546	-22,905
PLA Ppbd 12.7g max decomp	916	193	2.73%	366,010	8,232
PLA Ppbd 12.7g 0% decomp	92	-631	-8.93%	-111,949	-26,914
PLA Ppbd + 4.1g sleeve max decomp	1144	421	5.96%	167,791	17,957
PLA Ppbd +4.1g sleeve 0% decomp	131	-592	-8.38%	-119,324	-25,251
Greenhouse Gas Emissions for 32-oz Cold Cups (lb CO2 eq per 10,000 average weight cups)					
EPS 8.8g	1309				
LDPE Ppbd 19.8g max decomp	1555	246	3.48%	287,154	10,493
LDPE Ppbd 19.8g 0% decomp	143	-1166	-16.51%	-60,583	-49,734
Wax Ppbd 31.3g max decomp	2802	1493	21.14%	47,314	63,681
Wax Ppbd 31.3g 0% decomp	185	-1124	-15.91%	-62,847	-47,942
PLA 35g 50% heavier than 32oz PP	1419	110	1.56%	642,182	4,692
PLA 32.6g 39% heavier than 32oz PP	1314	5	0.07%	14,128,000	213
Greenhouse Gas Emissions for 9-inch Plates (lb CO2 eq per 10,000 average weight plates)					
Heavy-Duty Plates					
GPPS 10.8g	1142				
LDPE Ppbd 18.4g max decomp	1406	264	3.74%	267,576	
LDPE Ppbd 18.4g 0% decomp	206	-936	-13.25%	-75,470	
Mold Pulp 16.6g max decomp	1712	570	8.07%	123,930	
Mold Pulp 16.6g 0% decomp	532	-610	-8.64%	-115,803	
PLA 20.7g	840	-302	-4.28%	-233,907	
Lightweight Plates					
2009 GPPS 4.7g	497				
2009 LDPE Ppbd 12.1g max decomp	927	430	6.09%	164,279	
Greenhouse Gas Emissions for Sandwich-size Clamshells (lb CO2 eq per 10,000 average weight clamshells)					
GPPS 4.8g	529				
Fluted Ppbd 10.2g max decomp	681	152	2.15%	464,737	
Fluted Ppbd 10.2g 0% decomp	216	-313	-4.43%	-225,687	
PLA 23.3g	1492	963	13.63%	73,354	

Notes:

[1]: Franklin Associates, "Life Cycle Inventory of Foam Polystyrene, Paper-Based, and PLA Foodservice Products", 4 February 2011.

[2]: [1] - Equivalent Polystyrene Product Emissions in [1]

[3]: Assumes annual vehicle emissions at average California CAFE Standard levels and 12,000 driving miles per year. <http://www.dieselnet.com/standards/us/ca_ghg.php>

[4]: 1 / [3] * 10,000

[5]: Assumes 3 billion cups disposed of in CA per year. See Table 1.

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Biography

Dr. Mark Berkman is an expert in applied microeconomics. His experience spans the areas of the environment, energy, and natural resources; environmental health and safety; labor and employment; intellectual property; antitrust; commercial litigation and damages; and public finance. He has assisted both public and private clients and provided testimony before state and federal courts, arbitration panels, regulatory bodies, and legislatures.

His environmental work has involved the review of proposed air, water, solid waste, and worker and product safety regulations. Dr. Berkman has quantified the costs and benefits of these regulations, as well as toxic tort and product liability claims. In addition, he has valued natural and water resources as well as property damages associated with pollution from Superfund sites, landfills, and power plants.

His work on energy matters includes the valuation of coal resources, power plants, and transmission rights-of-way. He has also prepared energy demand and price forecasts. He has extensive experience working with Native American tribes on energy valuation matters.

Clients in a variety of industries ranging from computer chip to shoe manufacturers have sought Dr. Berkman's assistance to value patents, trade secrets, and trademarks. He has also been called on to address questions of market power in a variety of industries including solid waste, computer manufacturing, and medical devices. He has testified regarding market definition and market power and participated in Hart-Scott-Rodino proceedings.

Dr. Berkman also has substantial experience in labor and discrimination litigation. He has conducted statistical analyses of alleged discrimination in hiring, promotion, pay, and contracting, and completed damage analyses regarding these allegations. He has also conducted statistical analyses regarding mortgage lending discrimination.

Prior to joining *Brattle* he was a co-founder and director at Berkeley Economic Consulting and a vice president at both Charles River Associates and NERA Economic Consulting.

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Dr. David Sunding has extensive experience as a researcher, consultant, and expert witness in matters related to natural resources, environmental quality, energy, and the economics of regulation. His expertise includes experience in complex litigation, regulation, and transactions. He has testified in state and federal courts and in regulatory proceedings around the country.

He has assisted corporations, utilities, and government agencies in developing economic testimony in a variety of matters concerning environmental damages, product liability, risk assessment, resource planning, cost allocation, and project financing. Dr. Sunding has played a central role in several prominent water resource matters, including the landmark Quantification Settlement Agreement for the Colorado River, interstate water disputes before the U.S. Supreme Court, and the Federal Energy Regulatory Commission's relicensing of hydropower facilities. He has authored several widely cited studies on the economics of water quality regulation and has served as an expert in cases involving regulation and litigation under the Clean Water Act, the Endangered Species Act, and other statutes.

Dr. Sunding is the Thomas J. Graff Professor in the College of Natural Resources at UC Berkeley, where he is also the co-director of the Berkeley Water Center. He has received numerous awards for his research, including grants from the National Science Foundation, the U.S. Environmental Protection Agency, and private foundations. He is currently a Visiting Professor in the Woods Institute of the Environment at Stanford University.

Prior to joining *The Brattle Group*, Dr. Sunding was a founding director of Berkeley Economic Consulting. Previously, he was a senior consultant at Charles River Associates and NERA. He served as a senior economist for President Clinton's Council of Economic Advisers, and is a member of the American Economic Association, the Association of Environmental and Resource Economists, the Econometric Society, and the American Law and Economics Association.