# Evaluation of Greenhouse Gas Emissions Associated with Recycled-Content Products

## California Purchasing Guidelines for Carpet, Single-Use Alkaline Batteries, Monitors, Televisions, Laptops, and Tablet Computers

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# *Extended Producer Responsibility Evaluation of Greenhouse Gas Emissions Associated with Products*

## *Task 3d: Recycled Content Purchasing Guidelines*

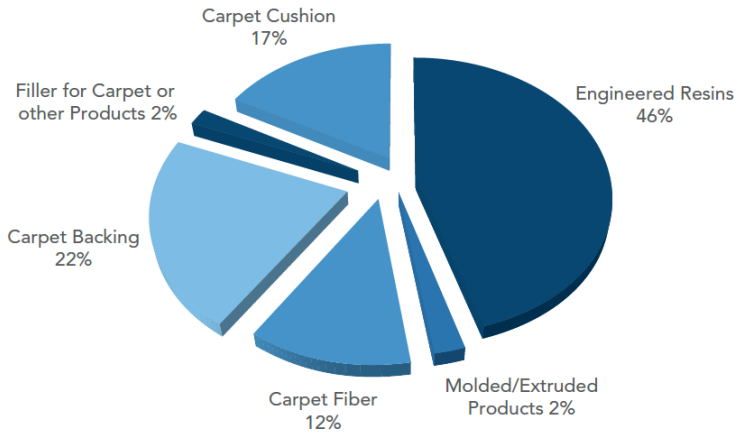
In this task, we developed California-specific recycled content purchasing guidelines for four selected products: carpet, single-use alkaline batteries, monitors and TVs, and laptops and table computers, to determine when a product purchased with recycled content has reduced associated greenhouse gas emissions as compared to a similar product made from virgin materials.

### Carpet

#### How much carpet is recycled in California?

Data on end-of-life disposition were obtained from the Carpet America Recovery Effort (CARE) 2010 annual report (CARE 2011), which documents detailed carpet waste recovery data for California. The CARE 2011 report states that 410 million pounds (186,000 metric tons, or Mg) of carpet were discarded from stock in California in 2010, and that 29 million pounds (7 percent, or about 13,000 Mg) and 47 million pounds (11 percent, or about 21,000 Mg) of this mass went to recycling and thermal recovery, respectively.

Figure 1 summarizes how the recycled carpet flows were further processed to produce different end use products, the most predominant of which is engineered resin pellets (CARE 2011). These data suggest that over half of the materials reclaimed from end-of-life carpets in California are used in future carpet manufacture, and that a sizeable fraction (46 percent) can be used to offset a high-grade virgin material (i.e., engineered resins). The thermal recovery fraction is mostly through waste-to-energy recovery facilities, with a minor fraction used as fuel substitutes in cement kilns outside of the state (CARE 2011).




*Source: CARE (2011)*

**Figure 1: Products manufactured from recycled carpets in California.**

## Does recycling save greenhouse gas emissions?

Figure 2 shows how the various end-of-life disposition pathways compare on a per-kilogram (kg) basis, which are based on end-of-life data from the reference (U.S. EPA 2011). Net landfill emissions include collection, transport, and landfill activities. Net recycling emissions include collection, transport, and recycling activities averaged across major end use products, and emissions avoided from substituting for virgin materials. Net waste-to-energy emissions include collection, transport, combustion, and emissions avoided from substituting for grid power. Thus, recycling 1 kg of carpet saves 2.6 kg of $CO_2$ equivalents ($CO_2E$), while both thermal recovery and landfilling are net $CO_2E$ emitters. Carpet recycling is clearly the best end-of-life option.

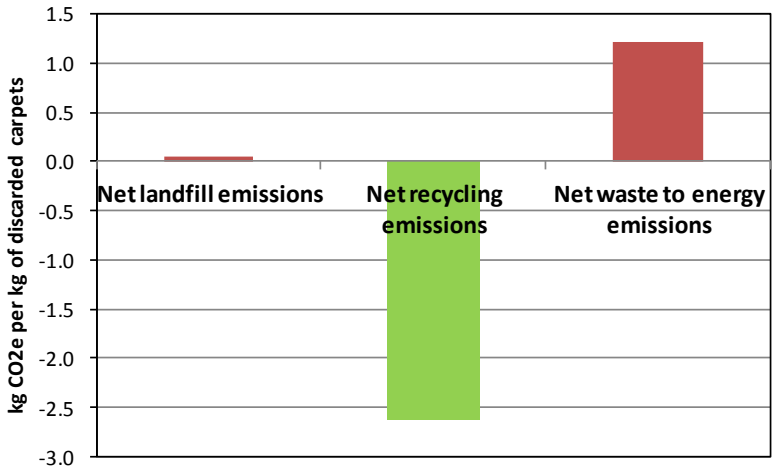



**Figure 2: Per-kg comparisons of different end-of-life pathways for discarded carpet.**

Figure 3 plots estimated total annual greenhouse gas emissions associated with California's end-of-life carpet mass flows in 2010. Current recycling results in emissions savings of about 34,000 Mg. Notable is that net emissions savings from current recycling slightly offset the combined net emissions outputs from current carpet landfill and thermal recovery operations in the state. The total net end-of-life emissions are estimated at -2,500 Mg $CO_2E$.

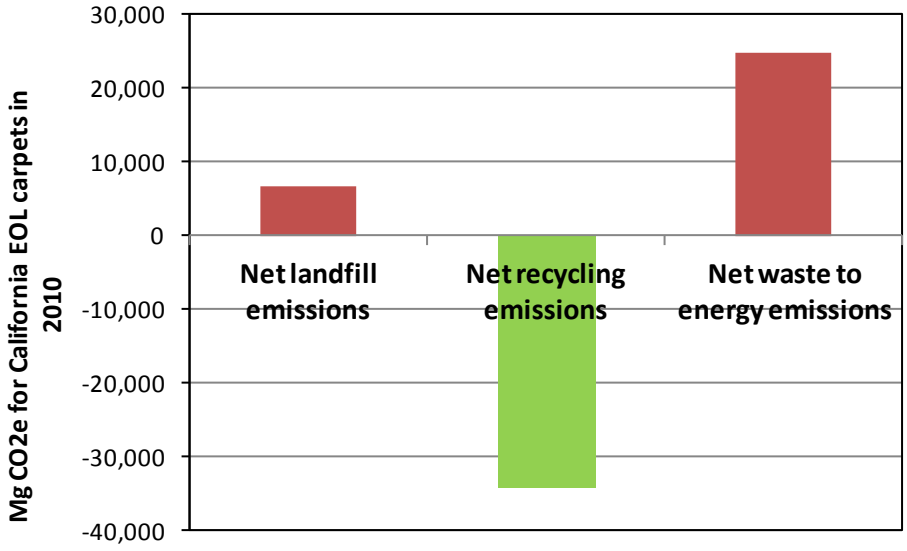



**Figure 3: Estimated total greenhouse gas emissions associated with end-of-life recycling/disposal, 2010.**

### How much is post-consumer recycled content in carpet, and how much can it be increased?

Many companies are increasing the use of post-consumer polymers as a feedstock for new carpets. The post-consumer recycled content of carpets can vary widely by both manufacturer and carpet component (e.g., facing, backing, or fillers). Data from the reference (CARE 2012) suggest that the current range of post-consumer recycled content by carpet weight is 20-50 percent.

### On average, there is no option to purchase carpet with 0 percent recycled content.

In the absence of data on the average post-consumer content of currently installed California carpets and recent California carpet purchases, the study team used an estimate of 10 percent for our base case. I.e., ***every carpet purchased contains around 10 percent post-consumer recycled content.*** We further assumed that this percentage could be increased to 20 percent or even to 50 percent based on data in the reference (CARE 2012).

### In 2010, purchasing carpet in California with 20 percent post-consumer recycled content would have resulted in greenhouse gas emissions savings of 23,500 Mg $CO_2E$. Raising the recycled content to 50 percent would have saved a 58,800 Mg $CO_2E$.

### How beneficial would maximum recycling of carpet be for greenhouse gas emissions?

For improved recycling, we assumed a theoretically maximum-achievable end-of-life carpet diversion and recycling rate of 100 percent. This assumption was implemented in the process-based life cycle assessment model by reducing landfill and waste-to-energy flows to zero and assigning 100 percent of the end-of-life mass to the recycling route. As previously discussed, the current recycling rate of California carpets is 7 percent of annual end-of-life mass. An important point is that this measure has overlap with the increased use of recycled content, in that the "credits" for materials recycling into new carpets are already accounted for in the methodology

for estimating the emissions savings of increased recycled content. Thus, the emissions reductions associated with this measure account for the additional offsets of virgin materials that would occur beyond the amounts that are used in California-purchased carpets.

**In 2010, if 50 percent of California's end-of-life carpet was recycled, 124,600 Mg $CO_2E$ could have been saved. With 100 percent of discarded carpet recycled, the savings could have been 203,600 Mg $CO_2E$.**

## Single-Use Alkaline Batteries

### What is the recycling rate for batteries in California?

In our April 2012 report for CalRecycle (Task 3 of the current project), "Single-Use Alkaline Battery Case Study," we estimated that 900 Mg of batteries were recycled and 15,100 Mg were landfilled in California in 2010.

### Does recycling of batteries save greenhouse gas emissions?

Figure 4 plots two cases for the 2010 end-of-life greenhouse gas emissions associated with spent alkaline batteries in California. The first case is the recycled mass, 900 Mg. We found that recycling saved about 50 Mg of $CO_2E$ emissions. The second case is the recycled mass and the illegal disposal of 15,100 Mg in landfills, which resulted in more than 1,400 Mg of emissions. The difference between these cases underscores the criticality of spent battery recycling from a life-cycle greenhouse gas emissions perspective.

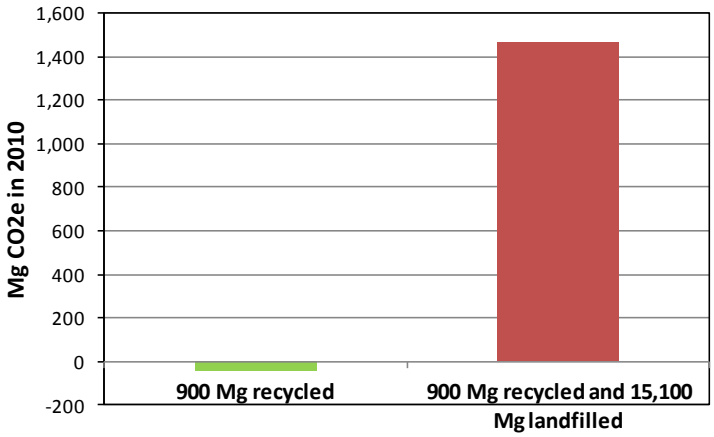



**Figure 4: Estimated total greenhouse gas emissions associated with end-of-life recycling/disposal, 2010.**

### How much is post-consumer recycled content in batteries, and can it be increased?

Alkaline batteries are mostly composed of a variety of metals by mass. The largest mass fractions are manganese (25 percent), zinc (19 percent) and steel (19 percent), with copper being about 0.2 percent. Different metals have different recycling rates (if they are recycled at all), and for a metal recycling rates may vary from location to location and manufacturer to manufacturer.

On average in the United States, the recycled content of steel made in basic oxygen furnaces is about 25 percent, while steel from electric-arc furnaces can have 90 percent recycled content. Zinc in the United States has about a 25 percent recycled content (earthmodal 2012), copper about 29 percent, while recycling of manganese is too small to report.

### All batteries purchased are likely to have some recycled content. Exactly how much is unknown.

***There are no alkaline batteries on the market that have identifiably higher recycled content.*** Battery manufacturers buy metals from the open market, and batteries are a small market for

metals, therefore unable to influence metal recycling rates. A higher recycled-content battery would come by when metals are recovered and recycled in higher proportions than currently. As the website (earthmodal 2012) shows, recycling of metals has been fairly steady in the surveyed period, and it is not known if future recycling rates would be any higher.

Therefore, as shown in the report "Single-Use Alkaline Battery Case Study," the strategy that would save the most greenhouse gas emissions is to recycle as much of the discarded battery stream as possible rather than focus on purchasing increased recycled-content batteries.

### How beneficial would maximum recycling of batteries be for greenhouse gas emissions?

We assessed a 100 percent recycling rate of all end-of-life batteries in California under the assumptions outlined in our "Single-Use Alkaline Battery Case Study." ***At 100 percent recycling rate, achieved through a retail drop-off system, 1,350 Mg of $CO_2E$ could have been saved in 2010.***

## Monitors and TVs

### What is the material composition of monitors and TVs?

A substantial weight percent of computer monitors and TV sets, whether older, CRT models or flat-panel models, is different types of plastics. Older CRT models contain glass, but new models do not. Just as there are no typical monitors and TVs, ***the weight and material compositions of these products are not publicly documented.***

### Does recycling of monitors and TVs save greenhouse gas emissions?

Assuming that monitors and TVs use the same types of plastics as computer enclosures, a study by Masanet and Horvath (2007) reported the results of a case study that included high impact polystyrene (HIPS), acrylonitrile butadiene styrene (ABS) and polycarbonate (PC)/ABS. Compared to landfilling, recycling 1 kg of PC/ABS and ABS saved about 2 kg of $CO_2E$ emissions. The greenhouse gas emissions savings from recycling 1 kg of HIPS were found to be 1.5 kg. Based on end-of-life data from the reference (U.S. EPA 2011), recycling 1 kg of glass could save emissions of 0.31 kg of $CO_2E$.

### How much is post-consumer recycled content in monitors and TVs, and can it be increased?

There is no specific information available on the recycled content of the types of plastics likely to be found in monitors and TVs. It is safe to assume that ***these plastics contain no recycled content***.

There are no data available about recycling the plastics likely to be found in monitors and TVs, therefore there is no current way to assess the savings associated with purchases of monitors and TVs that could be made with higher recycled content.

## Laptops and tablet computers

### What is the material composition of laptops and tablet computers?

A substantial weight percent of laptops and tablet computers is different types of plastics. Some laptops will have aluminum in their enclosure. Just as there are no typical laptops and tablet computers, the weight and material compositions of these products are not publicly documented.

### Does recycling of laptops and tablet computers save greenhouse gas emissions?

Assuming that laptops and tablet computers use the same types of plastics as computer enclosures, a study by Masanet and Horvath (2007) reported the results of a case study that included HIPS, ABS and PC/ABS. Compared to landfilling, recycling 1 kg of PC/ABS and ABS saved about 2 kg of $CO_2E$ emissions. The greenhouse gas emissions savings from recycling 1 kg of HIPS were found to be 1.5 kg.

### How much is post-consumer recycled content in laptops and tablet computers, and can it be increased?

There is no specific information available on the recycled content of the types of plastics likely to be found in laptops and tablet computers. It is safe to assume that ***these plastics contain no recycled content***.

There are no data available about recycling the plastics likely to be found in laptops and tablet computers, therefore there is no current way to assess the savings associated with purchases of laptops and tablet computers that could be made with higher recycled content.

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