State of Oregon
Department of Environmental Quality

# Briefing Paper:
# Materials Management and Greenhouse Gases

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## Introduction and summary

This document summarizes DEQ's current understanding of the interface between materials management and greenhouse gas emissions. It begins with a summary of the policy foundation in Oregon for reducing greenhouse gases. It then summarizes several studies that shed some light on how materials contribute to greenhouse gas emissions. It ends with a summation of opportunities to reduce greenhouse gas emissions through changes in materials management.

## Policy foundation

In 2007 the Oregon Legislature passed HB 3543. Section 1 of that bill includes legislative findings such as:

> "(3) Global warming poses a serious threat to the economic well-being, public health, natural resources and environment of Oregon."
>
> "(4) Oregon relies on snowpack for summer stream flows to provide energy, municipal water, watershed health and irrigation. Also, a potential rise in sea levels threatens Oregon's coastal communities. Reduced snowpack, changes in the timing of stream flows, extreme or unusual weather events, rising sea levels, increased occurrences of vector-borne diseases and impacts on forest health could significantly impact the economy, environment and quality of life in Oregon."
>
> "(6) Global warming will have detrimental effects on many of Oregon's largest industries, including agriculture, wine making, tourism, skiing, recreational and commercial fishing, forestry and hydropower generation, and will therefore negatively impact the state's workers, consumers and residents."
>
> "(7) There is a need to . . . take necessary action to begin reducing greenhouse gas emissions in order to prevent disruption of Oregon's economy and quality of life and to meet Oregon's responsibility to reduce the impacts and the pace of global warming."

Section 2(1) of HB 3543 states:

> "The Legislative Assembly declares that it is the policy of this state to reduce greenhouse gas emissions in Oregon pursuant to the following greenhouse gas emissions reduction goals:
> (a) By 2010, arrest the growth of Oregon's greenhouse gas emissions and begin to reduce greenhouse gas emissions.
> (b) By 2020, achieve greenhouse gas levels that are 10 percent below 1990 levels.
> (c) By 2050, achieve greenhouse gas levels that are at least 75 percent below 1990 levels."

The language of Section 2(1) suggests a focus on in-state emissions. However, via the development of its *Interim Roadmap to 2020*, Oregon's Global Warming Commission has indicated support for reducing all emissions associated with the life cycle of materials used in Oregon, even if some emissions occur out-of-state. This approach is justified as follows: 1) emissions of greenhouse gases effect global climate (and result in climate-related impacts in Oregon) regardless of whether emissions originate in Oregon or elsewhere; 2) if Oregon governments, businesses and residents have opportunities to reduce emissions, these opportunities should be considered regardless of whether actual emissions originate in-state or out-of-state; 3) Oregon has already established a precedent for addressing out-of-state emissions through the treatment of electricity in Oregon's traditional GHG inventory (which counts emissions associated with electricity used vs. in-state generation).

In addition, a narrow and exclusive focus on in-state emissions can lead to policy outcomes that are sub-optimal from both an environmental and economic perspective. For example, DEQ estimates that curbside recyclables collected from Portland, once used in the production of new products, reduce GHG emissions by approximately 40 times the emissions associated with collecting them. Clearly, curbside recycling in Portland is effective at reducing GHG emissions. However, most emissions reductions occur out-of-state. A narrow focus on reducing in-state emissions might lead to cancelling curbside recycling services, in order to reduce the (relatively small) in-state emissions associated with collection service. Such a move would be penny-wise and pound-foolish from a climate perspective as well as an economic perspective in a state where recycling creates a significant number of jobs.
Similarly, a narrow focus on reducing only in-state emissions would encourage purchasing of products from out-of-state producers but not in-state producers. DEQ assumes this was not the Legislature's intent.

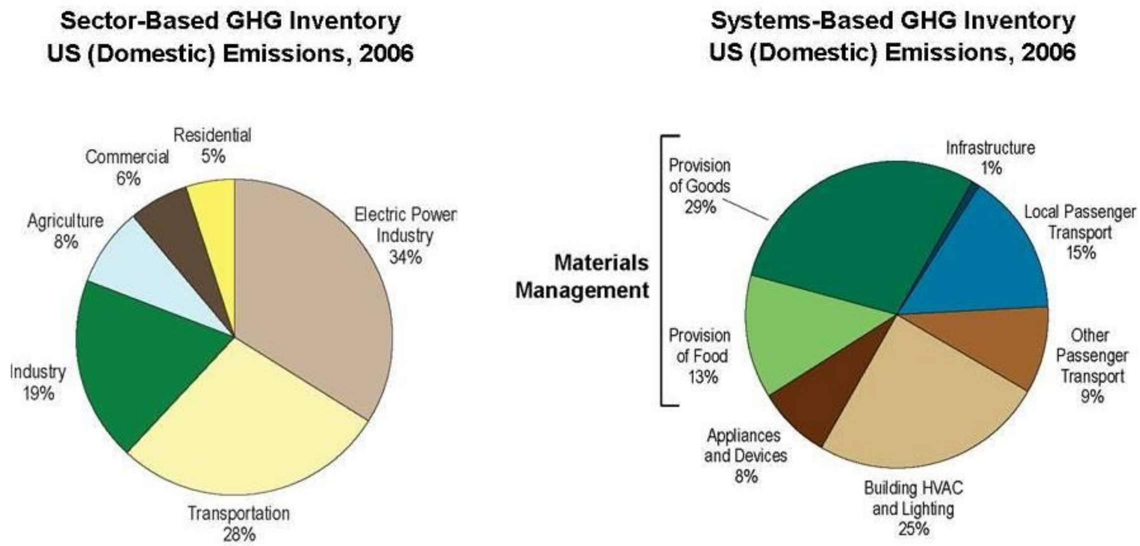
In addition to the legislative direction summarized above, Oregon's Global Warming Commission has included materials management as one of six broad areas in its *Interim Roadmap to 2020*, a package of recommendations for how the state can achieve its 2020 emissions reduction goal and make further progress towards achieving its 2050 emissions reduction goal.

## How do materials contribute to climate change?

### *EPA's "systems view" of emissions*

In the 2009 report Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land Management Practices, EPA estimated that 42 percent of domestic emissions are associated with the "provision of materials." "Provision of goods" contributes 29 percent while "provision of food" contributes another 13 percent. "Provision" refers to all life cycle stages except for use. Use of products contributes most of the remaining emissions (furnaces, lighting, air conditioning at 25 percent; vehicles, trains, planes and boats used for transporting people at 24 percent, and appliances and devices at 8 percent). This systems view of emissions is often compared with the traditional sector view, which assigns emissions to the sectors where emissions occur. One advantage of the systems view is that it highlights the significance of materials management, whereas emissions associated with materials are distributed throughout all of the sectors in the traditional sector view. See Figure 1.

**Figure 1.**
**EPA's Sector- and Systems-based GHG inventory of US (Domestic) GHG emissions, 2006**




Of domestic emissions associated with materials management, about 2.5 percent are associated with "waste" processes (primarily landfills), 7 percent are associated with movement of freight (primarily products and materials, but also wastes), and 33 percent are other "upstream" processes, such as resource extraction and manufacturing. It should be noted that the estimate of downstream emissions has higher uncertainty, primarily associated with challenges in estimating landfill methane emissions. However, even if EPA's estimates of landfill emissions are low by a factor of 2 or even 5, the emissions upstream of the consumer are significantly greater than emissions downstream (associated with discards management).

*Adjustments for exports and imports*

Looking only at domestic emissions (Figure 1) paints an incomplete view of the emissions profile of materials. Included in Figure 1 are emissions associated with goods produced in the United States but exported and used elsewhere. Not included are emissions associated with producing goods in other countries and importing them into this country. Because the U.S. is a net importer of goods and tends to import from countries with higher carbon fuel mixes, these "embedded emissions in trade" are significant.

When emissions of products made abroad and consumed here are included, and exports are subtracted, the emissions profile grows by approximately 12 percent (various authors have estimated increases ranging from 3 to 21percent), and products (including food) and packaging account for 49 percent of total emissions. That's considerably more than building energy consumption or passenger transportation – the conventional focus of climate action plans.

Again, while overseas freight adds to the emissions profile of imported goods, most of the added emissions result from production activities, not freight.

*Oregon's consumption-based emissions inventory*

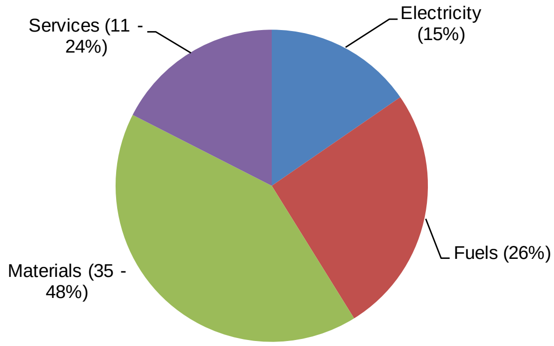
The estimates above are for the nation as a whole and lack detail about individual materials. A separate accounting effort – Oregon's Consumption-Based GHG Emissions Inventory (CBEI) – uses a different accounting framework to better understand the impact of materials. However, not all materials used in Oregon (or that become waste in Oregon) are included in CBEI. To understand, a short summary of CBEI is in order.

Traditional GHG inventories at the state or community scale typically focus on emissions originating within the community's geographic boundary. Sometimes, adjustments are made for imported electricity and exported garbage. In the case of Oregon, the traditional approach includes emissions associated with in-state production, but excludes emissions associated with producing imported goods. Consumption-based inventories take a very different approach. Using the economic definition of "consumption" ("final demand," or purchases by households and government, as well as investment purchases by businesses), consumption-based inventories estimate globally-distributed emissions associated with that consumption. So materials that are consumed directly (by Oregon households, government or as part of business investment) contribute to CBEI. Other materials *used* in Oregon (such as business supplies) only count if they are purchased as part of a supply chain that serves in-state consumption. For example, food purchased by a restaurant serving in-state residents (Oregon consumers) counts towards CBEI, but food purchased by the same restaurant when serving out-of-state visitors (not Oregon consumers) does not count.

Oregon's CBEI reflects only the 2005 calendar year. A few results of interest:

- Consumption-based emissions were approximately 78 million metric tons of carbon dioxide equivalent (MMTCO2e), while in-state emissions were only 53 MMTCO2e. Oregon is a net importer of goods and services that contribute to emissions.
- Consumption (final demand) of materials contributes 27 to 37 million metric tons of carbon dioxide equivalent, or 35 to 48 percent of the total inventory (41 percent on average) – more than fuels (26 percent) or electricity (15 percent). See Figure 2.
- Of emissions associated with material consumption (35 to 48 percent of the total), approximately 2 to 3 percent occur "downstream" (in disposal of post-consumer wastes); the remaining 97 to 98 percent are "upstream" of the consumer (in resource extraction, manufacturing and transportation). This does not include any emissions associated with the fuel or electricity used by energy-consuming materials (products). As noted above, those contribute another 41 percent to the total.

**Figure 2.**
**Summary of Oregon Consumption-Based GHG Emissions, 2005**
**Organized by Broad Categories of Final Demand**




- Higher-impact materials: Emissions associated with materials (excluding use of fuel and electricity by products) are distributed across many different commodity types. Looking only at household consumption (which contributes 81 percent of total consumption-based emissions), broad subcategories of materials with the highest emissions include clothing (1.7 MMTCO2e), red meat (1.6 MMTCO2e), vehicles (1.4 MMTCO2e), dairy products (1.1 MMTCO2e), medicines (1.0 MMTCO2e) and household supplies (1.0 MMTCO2e).
- Emissions intensity, a measure of emissions per dollar, provides a way of understanding how emissions might shift as consumer spending shifts from one commodity to another. For example, looking again at materials purchased by households, some subcategories such as dairy products (2.6 kg CO2e/$), red meat (2.5 kg CO2e/$), and a subcategory associated with mining of non-fuel minerals (2.4 kg CO2e/$) have emissions intensities significantly higher than average. By comparison, the emissions intensity of all household consumption is only 0.4 kg CO2e/$.
- At the level of individual commodities, model results are generally less precise. Regardless, it is interesting to consider which materials have both emissions and emissions intensities well above average. Materials with (non-use) household-related emissions in the highest quartile *and* emissions intensities also in the highest quartile include: several meats (beef, chicken, etc.), rice, several dairy products (milk, cheese, etc.), footwear, other leather products, fruit, vegetables, dolls/toys/games, paper and paperboard, greenhouse and nursery products, and pet food.
- About 54 percent of total consumption-based emissions occur out-of-state. Many of these emissions are not accounted for in the state's traditional greenhouse gas inventory.
- Emissions associated with production are much higher, on average, than emissions associated with freight transportation. While "local" products will have lower freight-related emissions, the overall carbon footprint of competing products is typically determined by differences in production, not distance of transportation.
- Locally and domestically produced goods may result in lower emissions than imported goods, on average. Given current import, production and energy mixes, if all goods consumed in Oregon but made in the U.S. were imported from other countries instead, at the same price as domestically-produced goods, Oregon's consumption-based emissions would be about 72 percent higher. This preliminary evidence suggests there may be a

greenhouse gas benefit to purchasing domestically-produced materials vs. imports, on average. More research is needed to validate this finding and apply it to specific product categories. This "local" advantage is mainly a consequence of differences in energy mixes and production practices, not impacts of transportation, as is commonly believed. On a case-by-case basis, for individual products, this "local" advantage may be higher or lower than average, and some domestic products will even have higher footprints than imports, particularly imports from countries with very low-carbon fuel mixes.

**Opportunities to reduce GHG emissions through materials management**

Before discussing opportunities for reductions, it is important to note that current materials management practices, while contributing significantly to greenhouse gas emissions, also contribute to some emissions reductions due to benefits such as reducing the need to extract and produce from virgin materials and providing substitutes for chemical fertilizers. For example, material recovery (recycling, composting and some energy recovery from waste) in Oregon in 2010 contributed to emissions reductions of about 3 million MTCO2e – the equivalent of about 4.3 percent of all state emissions, or the tailpipe emissions of 620,000 cars.[1] Recent changes in industrial and agricultural processes, packaging redesign and consumer shifts have also contributed to emissions reductions, although these are not as well quantified.

Looking to the future, further emissions reductions can be realized by changing how materials are made, used and managed at end-of-life. The state's "waste management hierarchy" (reduce, reuse, recycle, compost, recover energy, landfill) spans upstream (reduce) and downstream (recycle, compost, etc.) actions. However, it does not explicitly call out emerging downstream technologies (conversion technologies), and traditionally has been interpreted to focus just on waste. By extension, many upstream approaches, such as industrial ecology, product redesign, low-carbon production, and sustainable consumption, may be viewed by some as falling outside of the hierarchy, even though these practices may reduce wastes (not limited to solid wastes) over the entire life cycle of products.

The hierarchy of preferences often align with greenhouse gas reduction potentials (e.g., preventing the generation of a ton of any given material typically reduces emissions more than recycling that same ton; recycling is almost always preferable to composting, incineration or landfilling), but there are some exceptions. As examples: waste prevention and reuse do not always reduce emissions (in the case of home construction, for example); a vigorous controversy remains about whether composting, burning or landfilling is the lowest-carbon method of managing yard debris; and some materials (such as plastics) have lower GHG emissions if landfilled rather than combusted. So while the hierarchy is useful for making generalizations, optimizing management requires understanding the unique characteristics of materials on a case-by-case basis. Geographic differences can also come into play; what is "lowest carbon" in Portland may not be "lowest carbon" in Salem.

A 2011 report by the West Coast Climate and Materials Management Forum (http://www.epa.gov/region10/pdf/climate/wccmmf/Reducing_GHGs_through_Recycling_and_Composting.pdf) estimates that total recycling of carpet and "core recyclables" (corrugated

[1] Note that this is for recovery *from Oregon* that counts towards the state's recovery rate; it is not an evaluation of recycling activities *in Oregon* (for example, use of imported recyclables by in-state paper mills).

paper, office paper, newspaper, magazines, aluminum cans, steel cans and mixed plastics) from Oregon could reduce GHG emissions by an additional 0.7 to 1.0 million metric tons of carbon dioxide equivalent per year. Energy recovery from dimensional lumber and total composting of food waste offer added recovery potential of 0.5 MMTCO2e/year.[2] Summed together, emissions reduction potential for recovery of these materials is 1.2 to 1.5 MMTCO2e/year.

For purposes of comparison, consumption-based emissions for Oregon in 2005 were estimated to be 78 MMTCO2e/year. Thus, recycling and composting offer potential for emissions reduction, but that potential is relatively modest. Other approaches, including waste prevention, and changes in design and production methods and the quantity and types of products consumed and produced, offer potential for greater emissions reductions. Recent DEQ-commissioned studies of residential construction and drinking water delivery both emphasize the moderate emissions reduction potential associated with recycling and the greater emissions reduction potential associated with prevention and other product changes. Oregon's consumption-based greenhouse gas emissions inventory points in a similar direction; for example, GHG emissions associated with *producing* (globally) the food consumed in Oregon are about 30 times higher than emissions associated with disposal of post-consumer food. Food waste composting or anaerobic digestion offer the potential to reduce those post-consumer disposal emissions, but with estimates that as much as 40 percent of edible food in the U.S. is wasted (not eaten), the "upstream" emissions reduction potential of waste prevention is considerably higher.

The Global Warming Commission's *Interim Roadmap to 2020* contains 38 recommendations specific to materials management, and many other recommendations related to production of materials in Oregon (from the industry, forestry, agriculture, transportation and utility sectors). Among the materials management recommendations, nine "key actions" are:

- Advocate for a carbon price "signal" across the life cycle of products and materials (either by an emissions cap and/or a carbon tax), including imports (border adjustment mechanism/carbon tariff if necessary)
- Conduct research to develop a consumption-based GHG inventory and inventory methodology (DEQ recently completed this with the CBEI report described above); consider integration with Oregon's conventional inventory; identify high-carbon product categories
- Develop and disseminate information: easy-to-use life cycle measurements for different food types
- Establish standards, incentives and/or mandates for carbon footprinting, labeling of products
- Focus product stewardship on upstream emissions, and design for appropriate durability, repairability, reusability, efficiency and recovery

[2] Most emissions reductions from recycling of non-paper products are a consequence of displacing virgin feedstock in the production of new goods; these emissions reductions occur as soon as the recycled materials are used. In contrast, benefits from paper recycling are divided between energy savings, reduced landfill methane and increased carbon storage in forests. Those last two benefits are delayed, with emissions reductions occurring in smaller increments for many years after the paper is recycled. A similar dynamic holds for food waste composting, where benefits are divided between avoided landfill methane and increased soil carbon storage. So unlike many other actions that reduce GHG emissions, emissions reductions resulting from waste recovery are spread over time.

- Establish higher standards for new buildings: “net zero” GHG emissions plus offset of materials
- Provide information and outreach to consumers on product impacts and opportunities to reduce those impacts
- Prevent waste of food at the retail and consumer levels
- Conduct research on highest/best use for organic wastes, waste to energy, and the carbon impact of different conversion technologies.

Additional information on these key actions, as well as other recommendations, can be viewed at http://www.keeporegoncool.org/sites/default/files/Integrated_OGWC_Interim_Roadmap_to_2020_Oct29_11-19Additions.pdf.

A longer list of potential climate actions related to materials management is available from the West Coast Climate and Materials Management Forum. This list can be viewed at http://captoolkit.wikispaces.com/Climate+Protection+Actions.