Appendix D

Briefing Paper — Materials and Greenhouse Gases

Prepared for the Governor's Advisory Group on Global Warming
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This paper provides background information for members of the Governor's Advisory Group on Global Warming. Topics covered include:

- An overview of materials and waste in Oregon, including key definitions.
- An introduction to materials-related greenhouse gas sources and sinks.
- The rationale for developing a supplemental accounting of materials-related greenhouse gases.
- An overview of this supplemental accounting.
- An introduction to the basic methods of reducing materials-related greenhouse gas emissions, including waste reduction, energy recovery, and landfill controls.

The work of the Technical Subcommittee on Materials Use, Recovery and Disposal will be presented to the Advisory Group in two parts.

1. At the Advisory Group's May 12 meeting, the topics listed above will be summarized and time will be available for discussion.
2. Results of the supplemental materials accounting and the evaluation of specific materials-related measures (program and policy options) will be summarized at the Advisory Group's June 13 meeting for discussion at that time. Written materials will be forwarded in advance of that meeting.

Scope and Background: Materials and Waste in Oregon

The scope of the Technical Subcommittee on Materials Use, Recovery, and Disposal includes emissions and offsets associated with the production, use, recycling, composting, incineration, and landfilling of materials. The focus is on materials *used by and discarded by* Oregonians, as opposed to all materials *made in* Oregon. These include the many different types of materials that Oregon households and businesses discard for recycling, composting, or garbage collection.

The following types of materials are not addressed in this evaluation:

- Materials exported for *use out of state*. The in-state emissions associated with production and transportation of these materials are addressed by the energy and transportation subcommittees.
- Materials used in Oregon that are disposed of in wastewater systems, such as food and tissues. Some impacts from related wastewater processes (such as methane and nitrous oxide emissions from wastewater treatment plants) are addressed by the Technical Subcommittee on Other Greenhouse Gases.
- Materials managed as hazardous wastes and industrial and agricultural process wastes, such as slash from timber operations and crushed rock from mining, and materials exempted from the statutory definition of "counting" solid wastes, such as junked cars.

Once a material is no longer wanted by an Oregon household or business, it becomes a "waste". Roughly 35 percent of wastes discarded in Oregon in 2002 were either recycled or composted. The remaining wastes were either incinerated or sent to solid waste landfills. Most garbage in Oregon is landfilled, and Oregon is also one of the West's largest importers of garbage. In 2002, Oregon landfilled approximately

2.6 million tons of municipal solid waste from inside Oregon and another 1.4 million tons from other states, primarily Washington.

Some wastes, such as tires, dimensional lumber and used motor oil, are kept separated from mixed wastes and are burned as fuels by industry. In addition, Oregon has two mixed waste incinerators. Marion County's incinerator recovers energy while Coos County's does not. Approximately 12 percent of wastes discarded in Oregon in 2002 were burned for energy.

In addition to these known quantities of waste, which DEQ counts annually, an unknown quantity of waste is burned on-site or dumped in backyards or public lands.

A few notes regarding terminology: **Disposal** includes both disposal of waste at landfills and most disposal at garbage incinerators. **Waste recovery** includes recycling and composting, and in certain cases, thermal recovery of energy from waste. **Waste generation** is defined as the sum of disposal and recovery. It is largely synonymous with what households and businesses discard. **Waste prevention** means making less waste in the first place, such as more efficient use of materials. Waste prevention and **reuse** differ from recycling. In reuse, materials are used again in their original form, without the repulping, melting, grinding, or other mechanical or chemical reformulation associated with recycling. Finally, the term **waste reduction** incorporates all activities that reduce disposal, including waste prevention, reuse, recycling, and composting.

Per-capita waste generation (discards), as counted by DEQ, has risen more than 30 percent between 1992 and 2002. DEQ is currently evaluating this trend in an attempt to determine its causes. Some of the increase is explained by better reporting. Shifts in waste from on-site management such as backyard burning (which isn't counted in generation) to the system of recycling, composting and disposal (which are counted) also explain some of the rise in per-capita generation. Increases not attributed to better reporting and waste shifting are most likely attributable to increasing use, recovery, and disposal of resources.

Oregon statute includes a **waste management hierarchy**, which states that the preferred order for managing wastes are prevention, followed by reuse, followed by recycling, then composting, then energy recovery, and finally landfilling as the least preferred option. Also contained in law are **waste generation goals** and **waste recovery goals**, as follows:

- In 2005 and subsequent years, no increase in per-capita waste generation.
- In 2005, a waste recovery goal of 45 percent.
- In 2009 and subsequent years, no increase in total waste generation.
- In 2009, a waste recovery goal of 50 percent.

The state's waste recovery rate includes recycling and composting, as well as some energy recovery, and some adjustments for reuse and home composting. In 2002, the state's recovery rate was 46.6 percent. DEQ is concerned that the rate for 2003, which is currently being calculated, will fall as energy recovery from wood waste declined due to poor market conditions.

Materials-Related Greenhouse Gas Sources and Sinks

Greenhouse gas emissions and reductions associated with the production, recovery and disposal of materials and wastes are numerous and complex. In the United States, the U.S. Environmental Protection Agency's (EPA's) Office of Solid Waste and Emergency Response (OSWER) has funded and published some of the most comprehensive and definitive research on these topics.

The categories of emissions (sources) and offsets (reductions and sinks) recognized by OSWER include the following:

1. **Fossil fuel-derived energy in manufacturing** and natural resource extraction. This includes direct combustion of fossil fuels (for example, natural-gas fired boilers at paper mills) and the use of fossil fuels to generate electricity used by industry.
2. **Non-energy emissions from industrial processes**, such as carbon dioxide (CO_2) emissions from converting limestone to lime (used in the production of steel and aluminum) and methane emissions from natural gas processing associated with the manufacture of plastic products.
3. **Transportation-related emissions** including transporting raw materials to industry, manufactured products to customers, and discards to recovery and waste disposal facilities.
4. **Carbon storage in wood products and indirect carbon storage in forests** (related to changes in demand for timber as a result of recycling and reducing use of paper and wood). Increasing use of wood products increases the amount of carbon stored in products, while decreasing demand for timber is projected to indirectly increase carbon storage in forests.
5. **Carbon storage in agricultural soils** amended with composted wood, yard debris, and/or food waste. Soils that have been depleted of carbon have the potential to store carbon if treated with finished compost. (CO_2 from the decomposition or combustion of plant-based wastes is typically considered part of the natural carbon cycle and is not counted in most greenhouse gas inventories.)
6. **Methane emissions from landfills**. In the oxygen-poor landfill environment, a portion of carbon in waste is converted to methane. Many large landfills capture a portion of this methane and convert the carbon back to CO_2 through combustion.
7. **Carbon storage in landfills**. Slow-to-degrade materials, such as wood, may increase carbon sequestration if disposed of in landfills, thus offsetting methane emissions.
8. **Emissions from incineration of wastes**. These include nitrous oxide as well as CO_2 from the combustion of fossil carbon-derived materials such as tires, plastics, and synthetic textiles.
9. **Offsets from reductions in fossil fuel use resulting from energy recovery** of incinerated wastes or methane collected at landfills. Incinerators that recover energy from waste, and landfills that recovery energy from methane, offset the combustion of other fossil fuels elsewhere.

For any given material, several of these types of emissions and reductions or sinks may be relevant. For example, when comparing the recycling vs. disposal of paper, relevant categories of emissions include industrial energy for production of virgin and post-consumer paper, transportation, carbon storage in forests, methane emissions from landfills, carbon storage in landfills, and fossil fuel offsets from landfill gas energy recovery.

The relative importance of each of these types of emissions also varies widely between materials. For example, grass clippings, when landfilled, can produce significant quantities of methane, a potent greenhouse gas. In contrast, plastics and glass are relatively inert in landfills and generate little or no methane. For glass and plastic, their greenhouse gas profiles are dominated by manufacturing and transportation. Lawn prunings, on the other hand, are not manufactured and thus have no manufacturing-related greenhouse gas impacts.

One further complication is that some emission and reduction effects occur immediately, while others are delayed and extended over multiple years. For example, when material is disposed in a dry landfill, it may slowly generate methane for 100 – 150 years, or more. Depending on the accounting system used, landfill-related benefits of waste reduction may be assigned either to the year in which the waste reduction occurs, or in small increments in each of the years in which resulting methane emissions are reduced. The latter approach is used in this project. Landfill emissions in the year 2015, for example, are modeled as actual emissions *in that year* from waste disposed of in all previous years. Emission

reductions associated with carbon storage benefits at landfills, compost-amended soils, and forests (indirect) are also treated as occurring over multiple years. Advisory Group members should be aware that for some program and policy measures, actual emission reductions, over time, will be greater than what is estimated for the years 2015 and 2025.

Limitations of EPA's State Inventory Tool and Oregon's Inventory – The Need for a Supplemental Accounting of Materials-Related Greenhouse Gases

The EPA's State Inventory Tool provides a framework for inventorying a state's greenhouse gases. Oregon has chosen to use the State Inventory Tool (SIT) in support of the Advisory Group's work, with one major modification. Whereas the SIT assigns emissions from combustion of fossil fuels for electricity generation to the state where the electricity is generated, Oregon is choosing to assign these emissions to the state where the electricity is used. Thus, Oregon is assigned the emissions associated with the electricity we *use*, as opposed to the emissions from the electricity we *produce*. In other words, greenhouse gases associated with electricity generation are assigned to the state that is home to the *user* of the electricity, regardless of whether the electricity is generated in or out of state.

In contrast, state greenhouse gases associated with materials production are assigned not to the *user* of the material but rather the *producer*.

A consequence of this approach is that energy conservation and materials conservation are treated inconsistently. If Oregon is successful at reducing electricity use or shifting electricity purchases to non-fossil sources, Oregon will be assigned 100 percent of the reduction in emissions under the state's inventory. But if Oregon is successful at reducing waste, then reductions in upstream (manufacturing) emissions, which are often significant, will be assigned to the state where the material is produced (or where recycled wastes displace virgin feedstocks). Since many materials used in Oregon are not manufactured here, only a fraction of the benefit of waste reduction would be assigned to Oregon.

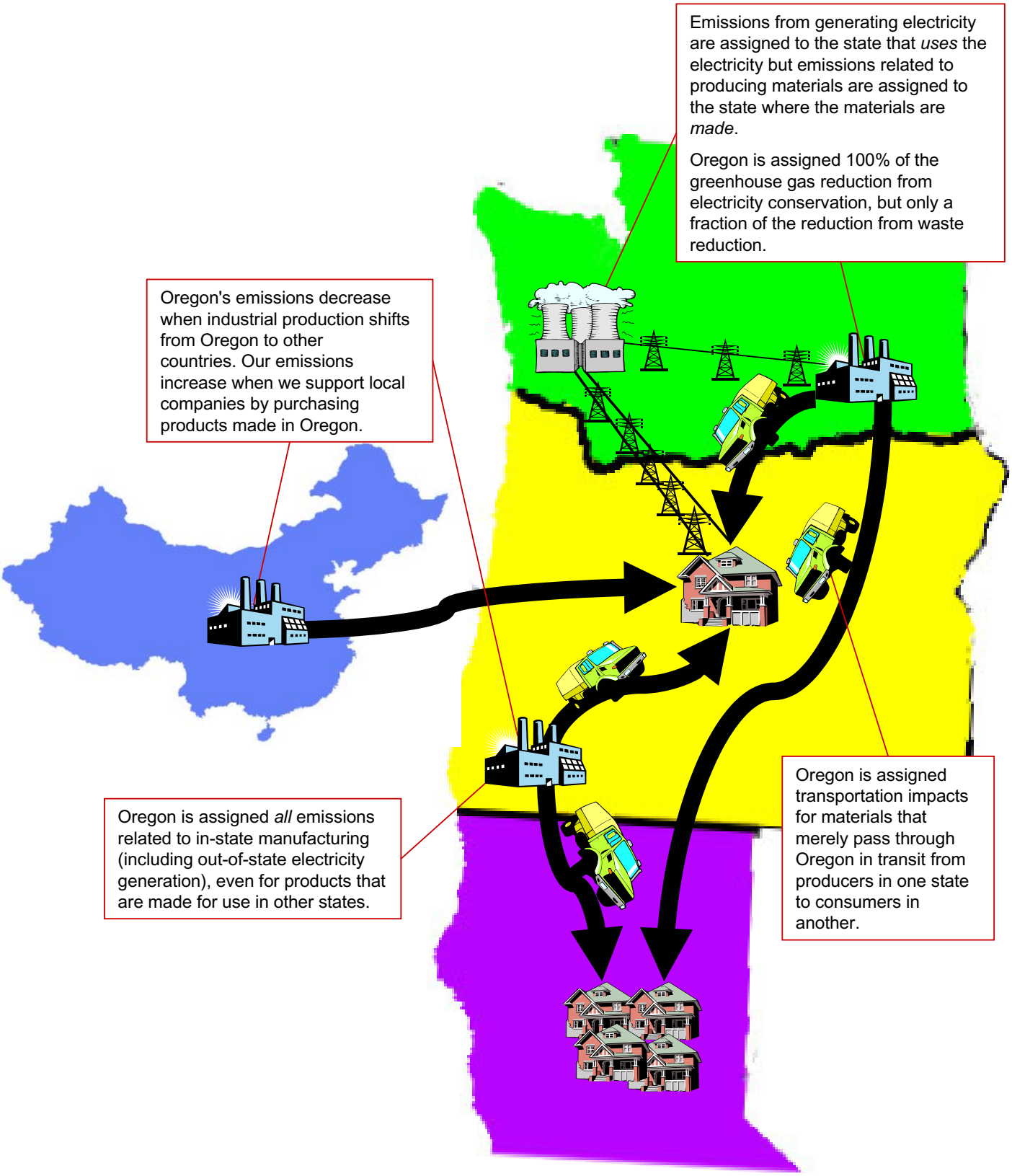
Other challenges with the SIT and Oregon's inventory framework include the following:

- Because resource extraction and manufacturing impacts are assigned entirely to the state (or nation) where the resource extraction and manufacturing occurs, out-of-state (or nation) consumers are assigned none of these impacts. All responsibility is assigned to the producer; none is shared with the consumer.
- Materials manufactured in state X, and shipped (by truck) through Oregon on their way to state Y for sale, cause Oregon to be assigned a portion of transportation impacts, even though Oregon neither produces nor uses the materials.
- Under both the SIT and Oregon's inventory, the shifting of production from Oregon to another state or country would be counted as an emissions reduction, even if global consumption and associated CO_2 emissions were unchanged. Conversely, if Oregon households and businesses shift consumption to locally-produced materials, a likely outcome of Oregon's inventory is that Oregon's greenhouse gas profile would appear to rise, even as global emissions probably fall (all other things being equal).

These issues are illustrated graphically in Figure 1.

Figure 1.

Oregon's Greenhouse Gas Inventory - How it Accounts for Material Production and Consumption



Our Solution: A Supplemental Accounting

The Technical Committee has decided not to make direct adjustments to the EPA's State Inventory Tool as part of this evaluation effort, other than for electricity. Instead, the Materials Subcommittee is developing a supplemental accounting of materials-related emissions. This supplemental accounting is being performed as a series of side calculations to the inventory. Results of the supplemental accounting will not be added to the Oregon inventory in order to avoid double-counting. However, this supplemental accounting will establish a framework whereby Oregon will be able to account for greenhouse gas reductions resulting from waste reduction initiatives in Oregon, even if they lead to changes in production and transportation outside of the state. Results of the supplemental accounting will be presented at the June 13 meeting of the Governor's Advisory Group and will also be shared with the EPA and the States of Washington and California in support of the activities of Working Group #5 (protocols).

In its simplest form, the supplemental accounting uses DEQ and EPA data on the composition of materials disposed and recovered in Oregon, as well as national sales, production, import, and export data to develop a model of materials use and discards in Oregon. For each type of material, EPA Office of Solid Waste and Emergency Response (OSWER) emissions factors for production, recycling, composting, landfilling, etc. are then applied. Adjustments are being made to some of these emissions factors to reflect Oregon-specific conditions, and to account for manufacturer-to-consumer transportation emissions, which were not included in OSWER's report.

Figure 2 illustrates the materials-related differences in what is included and excluded by the Oregon inventory and the Oregon supplemental accounting.

Strategies for Reducing Materials-Related Greenhouse Gases

Given the types of emissions noted above, three basic strategies for reducing greenhouse gases are:

1. Reduce fossil fuel use by waste prevention (more efficient use of products and packaging, reuse, using less), recycling of certain materials, and energy recovery from wastes and methane.
2. Increase carbon storage. Carbon storage can be increased in wood products, in soils (by composting and applying that compost to carbon-depleted soils), and in landfills (by landfilling certain carbonaceous materials). Indirect carbon storage can be increased in forests by recycling paper and preventing waste.
3. Reduce methane from landfills by reducing the landfilling of materials with large methane generating potential, controlling landfill conditions, and capturing methane emissions.

The Materials Subcommittee is currently evaluating a wide variety of materials- and waste-related measures. These will be presented to the Governor's Advisory Group at its June 13 meeting. The types of measures under study include both programmatic and policy changes. Examples include:

- Provide financial incentives or require enhanced methane collection at landfills (and energy recovery from that methane).
- Decrease the on-site burning of wastes, particularly fossil-carbon derived materials (plastics, tires, etc.) through education and/or increased regulation or enforcement.
- Provide additional funding to support the establishment and/or maintenance of enhanced waste reduction programs, such as food waste composting.
- Ban disposal in landfills of materials such as yard debris and recyclable paper, where the recovery infrastructure is well established.

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Figure 2.
Comparison of Oregon's Inventory and Materials-Related Supplemental Accounting

Type of Emissions	Oregon Inventory (SIT with adjustment for electricity generation)	Oregon Supplemental Accounting (materials-related)
Raw Materials Extraction, Product Manufacturing, and Transport of Products to Consumer		
Products made in Oregon		
and used/discarded in Oregon	Included[a]	Included
and used/discarded elsewhere	Included[a]	Excluded
Products made outside Oregon		
and used/discarded in Oregon	Excluded	Included
and used/discarded elsewhere	Excluded	Excluded
Municipal Solid Waste Disposal in Oregon (methane emissions)		
Waste generated in Oregon	Included	Included
Waste generated elsewhere and imported to Oregon	Included[b]	Included[b]
Waste Combustion in Oregon	Included	Included
Carbon Sequestration		
In landfills: yard debris	Included	Included
In landfills: other wastes	Excluded	Included
In compost	Excluded	Included
In wood products (in use)	Excluded	Included
In forests (indirect, resulting from waste reduction)	Excluded	Included

[a]Accounted for in non-waste modules (electricity use, industrial energy use, transportation fuel use).
[b]Only landfill-related methane emissions are counted for imported waste.

- Require loads of mixed waste to be sorted prior to disposal in high-population counties.
- Expand the bottle bill to cover more materials and/or increase the deposit value to reverse the decline in redemption rates.
- Encourage the more efficient use of materials (waste prevention) through education and incentives.

Advisory Group members with questions regarding the work of the Technical Subcommittee on Materials Use, Recovery and Disposal are welcome to contact the Subcommittee Chair directly at the following:

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