State of Oregon
Department of Environmental Quality

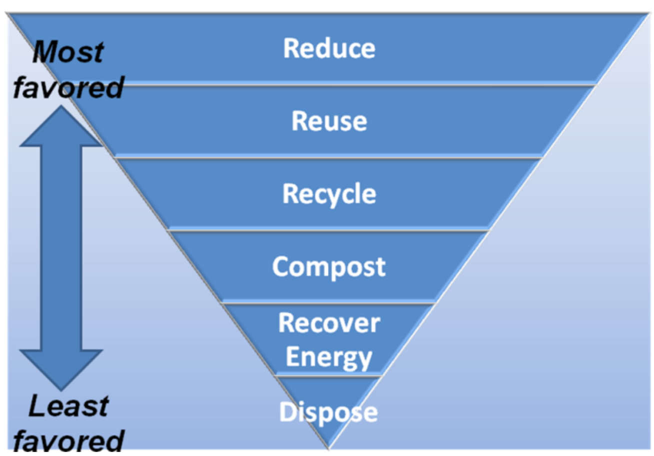
# Briefing Paper:
# Oregon's Solid Waste Hierarchy - Intent and Uses

**September 27, 2011**

Primary Authors: David Allaway & Peter Spendelow

"Reduce, Reuse, Recycle " has been part of the environmental lexicon since at least the first Earth Day in 1970, but Oregon was among the first states to adopt this as official policy in state law. The Recycling Opportunity Act of 1983 adopted a 5-step hierarchy for managing solid waste, with energy recovery and landfilling added below the other three. Passage of the 1991 Recycling Act added composting to the hierarchy below recycling and above energy recovery, so that the current law reads as follows:

**459.015 Policy.**
(1)....
(2) In the interest of the public health, safety and welfare and in order to conserve energy and natural resources, it is the policy of the State of Oregon to establish a comprehensive statewide program for solid waste management which will:
(a) After consideration of technical and economic feasibility, establish priority in methods of managing solid waste in Oregon as follows:
(A) First, to **reduce** the amount of solid waste generated;
(B) Second, to **reuse** material for the purpose for which it was originally intended;
(C) Third, to **recycle** material that cannot be reused;
(D) Fourth, to **compost** material that cannot be reused or recycled;
(E) Fifth, to **recover** energy from solid waste that cannot be reused, recycled or composted so long as the energy recovery facility preserves the quality of air, water and land resources; and
(F) Sixth, to **dispose** of solid waste that cannot be reused, recycled, composted or from which energy cannot be recovered by landfilling or other method approved by the Department of Environmental Quality.
(b).....




Separate legislation in 1991 directed that to encourage utilization of waste tires, energy recovery from tires would be considered recycling under the hierarchy (ORS 459.772).

**Intent and Uses of the Hierarchy**.

The hierarchy was established to guide solid waste management decisions. The intent of the solid waste hierarchy is primarily to conserve energy and natural resources, although other pollution-reduction benefits may also accrue. The direction to follow the hierarchy is not absolute, because the State is directed to also consider technological and economic feasibility.

DEQ interprets the hierarchy as policy guidance - not a hard and fast direction for how materials should be managed. For example, DEQ does not deny permits for facilities just because they are lower on the hierarchy. Further, if analysis shows that for a specific material, managing that material through a lower step of the hierarchy has lower environmental impacts and/or preserves more resources when compared to a higher step, then DEQ would tend to deviate from the hierarchy and stay true to its intent instead. However, conducting this type of analysis can be time- and resource-intensive. As a practical matter, DEQ recommends following the hierarchy as a coarse rule of thumb, but conducting case-by-case analyses for major decisions.

DEQ uses the solid waste hierarchy as a communication tool, to focus planning efforts, and to prioritize program activities.

- Communication. DEQ uses the hierarchy to encourage residents and businesses to reduce, reuse, recycle, and compost, in that order.
- Planning. The hierarchy has contributed to DEQ's emphasis in recent years on waste prevention, the "reduce, reuse" part of the hierarchy. This work is included in DEQ's Waste Prevention Strategy. The hierarchy also informs the State's existing *Integrated Resource and Solid Waste Management Plan (1995-2005*).
- Program prioritization. Oregon's system of solid waste fees supports the hierarchy, with higher fees imposed on waste-to-energy and landfill facilities, smaller fees on composting, and no fees on recycling or reuse tonnage. DEQ has also issued solid waste grants to help promote reduction, reuse, and recycling of materials in preference to disposal. In some of these cases, it may be that the understood environmental benefits resulting from managing materials higher on the hierarchy led to these actions, rather than direct reliance on the hierarchy itself. DEQ does not have authority to require individuals or organizations to follow the hierarchy, except to the extent that other specific laws or rules - such as disposal bans - allow such action.

**Does the Solid Waste Hierarchy Make Sense?**

Life cycle analysis by DEQ and others confirms that the hierarchy generally provides good guidance relevant to energy, resource, and pollution impacts for different methods of managing solid waste.[1] Prevention typically conserves the most resources and reduces the most pollution. Similarly, reuse is generally preferable to recycling. For materials that could either be recycled or composted (such as paper), recycling is almost always preferable to composting. Recycling conserves more resources than energy recovery, and landfilling conserves the fewest resources.

[1] Recent DEQ research has focused on comparing the upper tiers of the hierarchy (e.g., prevention and recycling, and sometimes composting). For examples, please refer to DEQ life cycle analyses of drinking water delivery, residential home construction, and e-commerce packaging.

### Energy and Resource Conservation

The US Environmental Protection Agency compared the net, per-ton energy impacts for source reduction, recycling, combustion, and landfilling of 40 different materials and groups of materials[2]. On a ton-for-ton basis, source reduction saves more energy than recycling for 90 – 95% of materials studied. Recycling saves more energy than combustion for 81% of materials studied. And combustion saves more energy than landfilling for 94% of materials. Source reduction and recycling also conserve other, non-energy resources, such as minerals and wood fiber, whereas combustion does not. From a resource conservation perspective, the hierarchy generally makes sense.

Composting is not evaluated by EPA for energy conservation benefits. Composting can both use energy, and result in energy conservation, particularly if finished compost improves soil fertility (more agricultural output for fewer inputs) or otherwise reduces the need for energy-requiring inputs such as fertilizer and water. Like recycling, composting also conserves non-energy resources, particularly soil quality, which is a critical element of food security.

### Pollution Reduction

Regarding pollution reduction, EPA's analysis extends only to greenhouse gas emissions. The results here are similar, but not identical to the energy results above. On a per-ton basis, source reduction is found to reduce greenhouse gas emissions relative to recycling for 81% of materials compared. Recycling, in turn, is preferable to combustion for 96% of materials studied, and recycling is preferable to landfilling for 100% of materials studied.

Things get messier in the lower tiers of the hierarchy. EPA did not compare the relative greenhouse gas benefits for materials that could either be recycled or composted (such as paper), but recycling is likely far more advantageous. Composting compares favorably against combustion (for 85% of materials) and also against landfilling (for 75% of materials), but results can vary depending on site-specific conditions. Combustion results in fewer GHG emissions than landfilling for 59 – 68% of materials studied by EPA. More recent analysis by Dr. Jeff Morris of Sound Resource Management Group suggests that neither landfilling nor combustion, viewed holistically, actually reduce emissions, and that the relative advantage of one over the other depends on a host of site-specific factors, including gas collection efficiency, waste composition, electricity conversion efficiency, heat capture, scrap metal recovery, greenhouse gas (GHG) intensity of displaced power, and time horizon.

More comprehensive evaluation in Europe has found that recycling, on average, typically reduces other pollutants (other than greenhouse gases) more than energy recovery (combustion) or landfilling.

## Limitations of the Hierarchy

There are case-by-case exceptions to the hierarchy, where the relative ranking of alternatives in the hierarchy doesn't always align with actual resource conservation or pollution reduction, or rankings may align for one environmental measure but not for another. This is often the case when the use phase of an object's life cycle has more environmental impact than the manufacturing and the end-of-life phase. For example, a new house built with no insulation and thin walls uses less energy and material in construction, and generates less waste than a house with good insulation and thick walls. Over the course of its life though, the house without insulation will use far more energy for heating and cooling

[2] See http://www.epa.gov/climatechange/wycd/waste/downloads/energy-impacts-chapter10-28-10.pdf and data in EPA's WARM model http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html for more information.

and will generate far more greenhouse gas than will the house with insulation and thicker walls. This is true even if the insulation and walls are not recyclable, or recycled.

Another example where the hierarchy may not always make sense involves reuse, particularly if the item being reused is particularly impactful, or if the reuse process itself requires extensive transportation and/or washing. Reuse often makes good environmental sense. For example, DEQ has shown that drinking from a reusable water bottle, even if washed frequently in an inefficient home dishwasher, conserves resources and reduces most pollution relative to drinking bottled water and recycling the bottles. But in contrast, the reuse of an old, energy-wasting refrigerator is probably worse than destroying the refrigerator via recycling, and replacing it with a new, energy efficient model.

Some research suggests that energy recovery from waste wood may be preferable to recycling the wood back into products (such as particleboard). This is because virgin wood requires relatively few resources to produce, while the recovery of energy from combusted waste wood may provide a large benefit if fossil fuel combustion is displaced. The greenhouse gas trade-offs between source reduction, recycling, and energy recovery of waste wood are complicated by uncertainties regarding carbon storage in forests.

**Case Study: Degradable and Compostable Plastics**

Environmental benefits are not as clear cut lower on the hierarchy, particularly with regard to composting. Consider the case of degradable or compostable plastics that have been collected at the end of their life and that could be recycled, composted, burned for energy recovery, or landfilled. A certain amount of energy and resources went into making that plastic. Even if the plastic was bio-based, some fossil fuel energy likely went into producing fertilizer, growing the crop, harvesting and transporting it, and manufacturing it into plastic. If that plastic can be successfully recycled, it should displace some of the fossil fuels and other resources that go into producing new plastic, while continuing to sequester the carbon in the plastic from the atmosphere. If burned for energy recovery, the carbon will be released to the air as carbon dioxide, but the energy recovery will displace the burning of other fossil fuels. If landfilled, it is not clear what will happen to the plastic, although the resource will have been wasted. If it does not decompose under landfill conditions, then it sequesters carbon in the landfill, reducing global warming impacts. If the plastic decomposes when landfilled though, this would be an even worse result, since it could release a significant amount of its carbon to the atmosphere as methane - a gas which is about 23 times more potent than carbon dioxide.

When composted though, some of the degradable plastics break down almost completely to carbon dioxide and water, and do not contribute significantly to the formation of rich humus produced by composting plants and woody residue. The plastic thus ends up releasing almost all of its carbon to the atmosphere contributing to the build-up of global warming gases, but without any recovery of the energy or other resource that was embodied in the plastic. From a greenhouse gas and energy perspective, this is a relatively bad result, since it results in little usable product, releases nearly all of its carbon to the atmosphere, and does not make use of the energy embodied in the plastic. There are legitimate reasons to use biodegradable or compostable plastics such as for items that might be commonly littered or that are mixed in with food waste or used for organics collection. However, for plastics that do not need to be degradable, recycling, energy recovery, and even landfilling may be preferable to composting at the end of life.

Besides greenhouse gases and energy conservation, impacts on ecological services provided by forests also weigh in this debate.

In addition, the hierarchy has several other limitations.

The hierarchy is not nuanced, in that it does not address options within each step of the hierarchy. For example, glass can be melted to make new bottles, melted and spun into fiberglass, used to make glass tiles, or crushed and used as aggregate. These different recycling methods for glass all have substantially different environmental benefits and costs. As another example, there are many forms of energy recovery, including mass-burn of mixed waste, separation and burning/energy recovery of only high-energy wastes, pyrolysis and gasification, biological production of ethanol, and anaerobic digestion. Some of these processes could even manage a waste (or different components of the same waste) using more than one step of the hierarchy. Pyrolysis, for example, could be used mainly to produce fuels for energy recovery, but can also produce some feedstock products that can be recycled into material objects such as plastics. With these complications, generalizations from the solid waste hierarchy may not be sufficient, and individual analysis of options should be done.

Different alternatives may rank in different order of preference depending on what objectives one is hoping to achieve. One example of this is the pyrolysis of waste plastic, whereby plastic is chemically treated to revert back to liquid hydrocarbons ("synthetic crude"). From an energy conservation perspective, it appears that recycling is still better than pyrolysis, while pyrolysis is better than mass burn (e.g., Covanta), and far better than landfilling. However, when viewed from the perspective of greenhouse gas emissions, recycling remains on top, but landfilling may actually be better than pyrolysis (although not by much), and is far better than mass combustion. Similarly, composting may be better than anaerobic digestion at conserving soils, while anaerobic digestion likely offers a great displacement of fossil fuels.

Finally, the hierarchy was designed as a guideline for managing discards. Applying it to purchasing decisions may not always provide the best result, particularly when evaluating very dissimilar materials. Several studies by DEQ and others show that making purchasing decisions with the hierarchy in mind may lead to inconsistent environmental results – sometimes good, sometimes not. For example, as discards management options, recycling and composting are typically preferable to landfilling. But when the question shifts from "how do we best manage our discards?" to "what should we buy?" the hierarchy is less reliable. Due to differences in how they are made, and the importance of these "upstream" (pre-purchase) impacts, recyclable and compostable materials are not inherently "better for the environment" or less impactful than materials that are difficult to recycle or compost. When comparing materials with very similar upstream impacts, using the hierarchy to facilitate better end-of-life management probably makes good sense. But when comparing materials with very different upstream impacts, the hierarchy is less useful – again, because the upstream impacts tend to dominate. In some cases, even a non-recyclable material sent to the landfill will have lower environmental impacts than a recyclable or compostable alternative recovered at moderate recovery rates (for example, see DEQ's comparison of shipping bags and cardboard boxes used in e-commerce). Put differently, just because a material is readily recyclable or compostable, does not necessarily make it a good environmental choice, when viewed holistically.

### Summary

Oregon's solid waste hierarchy is a simple decision framework that establishes the following priority in methods of managing solid waste: reduce, reuse, recycle, compost, recover and dispose. The hierarchy was last revised in 1991, and as technology changes, and as demand and prices for energy increases, the hierarchy is increasingly being questioned, particularly the relative placement of the lower tiers of composting, energy recovery and landfilling.

DEQ's research confirms that the hierarchy is generally a useful tool, but it has its limitations. It works best as a communication tool, to focus planning efforts, to prioritize program directions at a coarse scale, and to make quick decisions that have relatively small impacts. For decisions that involve large commitment of resources or have the potential of having significant environmental impacts, DEQ believes that additional environmental analysis may be warranted.