State of Oregon
Department of
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Quality

# Briefing Paper:
# What are "Sustainable Materials" and "Sustainable Materials Management"?

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Primary Authors: David Allaway & Peter Spendelow

What is a sustainable level of material or resource consumption? The 1994 Oslo Symposium on Sustainable Consumption defined "sustainable consumption" as:

> "the use of services and related products which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generations."

While useful conceptually, the previous definition may be difficult to apply in practice. When it comes to materials, is it possible to define in more detail the meaning of "sustainable materials management"? How would we know if a material (and its management) actually is "sustainable"? What would be the attributes of such a material? More broadly, how would we know if any action is sustainable?

Various thinkers and organizations have proposed a variety of answers to these questions – sometimes specific to materials, other times about sustainability more broadly. This paper briefly introduces six different responses, and summarizes some of the advantages and limitations of each. The six responses are:

- William McDonough and Michael Braungart's "Cradle to Cradle" and philosophy of "Waste Equals Food"
- Zero Waste
- The Natural Step
- The Ecological Footprint
- The Sustainable Packaging Coalition's "Definition of Sustainable Packaging"
- Internalizing Externalities / Least-Cost Planning

## Cradle to Cradle and "Waste Equals Food"

Summary: Architect William McDonough and chemist Michael Braungart popularized the theory of "Cradle to Cradle," explained in their 2002 book *Cradle to Cradle: Remaking the Way We Make Things*. In their book, McDonough and Braungart criticize most environmental initiatives (including "reduce, reuse, recycle") as examples of "eco-efficiency." Eco-efficiency merely slows down a failed system, delaying but not ending environmental and social decline, they claim. It "presents little more than an illusion of change," fails to provide a fun or inspiring vision, and merely serves as "guilt management for our collective sins." Recycling and composting are criticized for distributing toxic materials and wasting resources as a consequence of downcycling, a consequence of failure to design products for optimal recycling. For example, metals in cars are a variety of higher- and lower-value alloys, but current recycling practices mix all steel together, compromising the higher quality steel and copper and drastically reducing its future use. "The agenda to recycle has superseded other design considerations . .

. Blindly adopting superficial environmental approaches without fully understanding their effects can be no better – and perhaps even worse – than doing nothing.”

McDonough and Braungart offer a radically different vision: “eco-effectiveness” (regenerative, positive and productive) as opposed to “eco-efficiency” (“being less bad”). Eco-effectiveness is a positive characteristic where growth is good and more is better, as eco-effective materials give back to the environment more than they take. This focus on a positive vision may be one reason for the popularity of this philosophy.

Inspiration is drawn from nutrient cycling in nature, which is “sustainable, fecund, and productive.” In nature, according to McDonough and Braungart, “waste equals food.” To be sustainable, materials must be either “technical nutrients” that are designed for perpetual recycling via manufacturing, or “biological nutrients” that can be “recycled” by natural systems. “If our systems contaminate Earth’s biological mass and continue to throw away technical materials (such as metals) or render them useless, we will indeed live in a world of limits, where production and consumption are restrained, and the Earth will literally become a grave . . . If humans are truly going to prosper, we will have to learn to imitate nature’s highly effective cradle-to-cradle system of nutrient flow and metabolism, *in which the very concept of waste does not exist*.” For this to be realized, biological and technical nutrients cannot be mixed, and all materials must be designed for proper recovery (and recovered). “Eco-effectiveness” is also contrasted with “sustainability,” which is criticized for being “not very exciting.”

“Cradle to cradle” also highlights the importance of respecting diversity, emphasizing that what is sustainable in one location may not be suitable elsewhere due to differences in climate, solar and natural energy flows, culture and landscape.

McDonough and Braungart’s book closes with five principles: 1) signal your intentions; 2) strive for restorative growth, not just economic growth; 3) be ready to innovate further; 4) understand and prepare for the learning curve; and 5) exert intergenerational responsibility.

<u>Advantages:</u> “Cradle to cradle” presents a positive, fun vision of a future without constraints, where businesses and commerce can thrive and individuals can feel good about buying, using and discarding resources, as all materials are “restorative” or at least free of negative impacts. Perhaps for this reason, McDonough and Braungart have attracted a wide following and their philosophy has been very influential.

The vision of “waste equals food” and total recirculation of technical and biological nutrients comports with most other definitions of sustainability. Indeed, it is difficult to imagine a sustainable society where resources are wasted to any significant extent – particularly non-renewable resources, but also renewable ones, given the resources and impacts commonly associated with producing them.

McDonough and Braungart identify our current environmental problems as being failures of design. By emphasizing the importance of design and designing for sustainability, they shine a spotlight on the importance and responsibility of producers to effect change. Similarly, their perception that the “problem of waste” is not a problem of landfill space, but rather the contamination, waste or loss of resources, suggests that while all “waste reduction” approaches may share the benefit of keeping waste out of landfills, the actual benefits of different approaches may be very different. The concept that not all waste reduction is the same is in alignment with the waste management hierarchy.

<u>Limitations:</u> “Cradle to cradle” appears to assume that, properly designed, totally recyclable (and recycled) products would be sustainable. The same is true for totally degradable “biological nutrients.” It is easy to over-simplify cradle-to-cradle philosophy to focus on the very beginning and end of the

product life cycle: eliminating the use of virgin resources (at least non-renewable ones) and eliminating waste. Very little discussion is given to all of the environmental impacts that occur in the middle of the life cycle, which include manufacturing, transportation and use. In fact, for many products, this is where many of the most significant impacts occur. Merely maintaining materials in closed technical or biological loops may still be fundamentally unsustainable, depending on what other steps occur inside those loops.

For example, McDonough and Braungart discuss a compostable upholstery fabric they designed. Their solution was to “design a fabric that would be safe enough to eat: it would not harm people who breathed it in, and it would not harm natural systems after its disposal. In fact as a biological nutrient, it would nourish nature.” Specifically, the material chosen was a mixture of plant and animal fibers: ramie (an Asian tropical herb) and wool. Because of smart design, the pollution from the manufacture of the textile was radically reduced. It is celebrated as embodying “the kind of fecundity we find in nature’s work. After customers finished using it, they could simply tear the fabric off the chair frame and throw it onto the soil or compost heap without feeling bad – even, perhaps, with a kind of relish . . . giving a guilt-free gift to the natural world is an incomparable pleasure.” In other words, because the material came from nature and is returned to nature, it is sustainable. No discussion is given to whether or not the “natural” systems required to produce the raw materials are sustainable. Specifically, most wool comes from sheep, and sheep have the potential of producing significant amounts of methane, a potent greenhouse gas. The grazing of sheep can also require large amounts of land and negatively affect such land (if not done properly).

Similarly, the growing of any crop – ramie for upholstery or soybeans for biodiesel – requires resources (including land) that only exist in finite supplies. While McDonough and Braungart envision a world without limits, no recognition is given to unbreakable natural laws that impose limits upon all endeavors. These include the 2$^{nd}$ Law of Thermodynamics, which states that all processes (“natural” or otherwise) result in waste. Even the assertion “there is no waste in nature” is not correct, when viewed through the lens of the 2$^{nd}$ Law. Another important limit is that to be sustainable, humankind’s use of energy is essentially limited to the amount of solar gain. While the solar resource striking our planet is immense, much is currently dedicated to agricultural activities, and the potential of agricultural lands to produce materials is limited by constraints of land, water and climate.

The idea of “waste equals food” runs the risk of being oversimplified, to focus just on municipal solid waste (as opposed to all wastes, including emissions). Repurposing *all* wastes (including emissions such as greenhouse gases and toxic chemicals) would bring society much closer to sustainability. In contrast, merely repurposing all municipal solid waste focuses on just one type of waste (garbage) and not other emissions (wastes) across the full life cycle. While increased recycling and composting would often reduce environmental impacts, this is not always the case, and doing so might not be the optimal pathway; to quote the book, “Blindly adopting superficial environmental approaches without fully understanding their effects can be no better – and perhaps even worse – than doing nothing.” A narrow focus on “waste repurposing” also disregards the benefits of prevention (avoiding the production of wastes in the first place, often by using fewer materials), but prevention is criticized as an example of “being less bad.”

McDonough and Braungart use conventional “eco-efficiency” as a foil to demonstrate the advantages of “eco-effectiveness” and “waste equals food.” But currently, very few (if any) products or materials are truly and fully eco-effective. In the meantime, what are governments, businesses and households to do? Throw out efficiency measures entirely? A tension exists between the vision of a future without limits and the reality of limits in our current world. “Cradle to cradle” offers a vision of a path out, but with gaps and pitfalls that may not make it useful to apply in practice.

## Zero Waste

Summary: “Zero waste” is a difficult framework to characterize because it means different things to different people. To some, “zero waste” applies only to solid waste, and represents a goal of ending (or dramatically shrinking) the flow of resources to landfills and incinerators. An alternative approach treats incinerators as a recovery option. Others take the reverse position, avoiding incineration while allowing landfilling. Still others take a much broader view, limiting “zero waste” not just to solid wastes, but addressing all wastes across the full life cycle of products, including other pollution (such as greenhouse gas emissions) and other flows of matter into the environment that represent unutilized/wasted resources.

For the purpose of this paper, we focus on the first definition because it is the best documented and most commonly used. The Zero Waste International Alliance provides the following definition:

> “Zero Waste is a goal that is ethical, economical, efficient and visionary, to guide people in changing their lifestyles and practices to emulate sustainable natural cycles, where all discarded materials are designed to become resources for others to use.
>
> Zero Waste means designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them.
>
> Implementing Zero Waste will eliminate all discharges to land, water or air that are a threat to planetary, human, animal or plant health."

The Zero Waste International Alliance goes on to say “This is the goal we are striving for. Measures of success in meeting this goal are outlined in the Zero Waste Business Principles and the Global Principles for Zero Waste Communities. Businesses and communities that achieve over 90% diversion of waste from landfills and incinerators are considered to be successful in achieving Zero Waste, or darn close.”

According to the Zero Waste International Alliance, “Zero Waste involves moving from the back end of waste disposal to the front end of resource management. If a product can't be reused, repaired, rebuilt, refurbished, refinished, resold, recycled or composted, then it should be restricted, redesigned, or removed from production.”

Advantages: “Zero waste” (narrowly defined just to apply to solid waste) represents a powerful communications platform. The concept is easy to understand and communicate, seems intuitively reasonable, and is difficult to oppose. Zero Waste’s emphasis on reduce/reuse/recycle/compost is largely consistent with the existing waste management hierarchy, both in emphasizing the higher priority management options, and also in narrowly focusing just on solid waste. Compared with other approaches outlined in this paper, zero waste is the closest to, and shares the most in common with, existing solid waste policy. This is perhaps not surprising, as many leaders in the zero waste community have deep roots in solid waste management and recovery. One difference, however, is that while the hierarchy acknowledges a place for energy recovery and landfilling (albeit as options of last resort), zero waste philosophy strongly discourages these options.

Limitations: A narrow focus on solid waste is a potential concern, in part because zero solid waste will not eliminate all emissions across the full life cycle of products. Also, there may be cases where reducing solid waste causes other environmental impacts to increase. While reducing solid waste often correlates with reductions in other environmental impacts, this is not always the case. For example, home builders could make houses more recyclable (and reduce waste) by avoiding materials such as insulated concrete forms and structural insulated panels, but doing so would increase energy consumption and associated environmental impacts over the life of the home. Sometimes non-recoverable materials have lower environmental impacts than recoverable/recovered materials.

The statement in the definition that “Implementing Zero Waste will eliminate all discharges to land, water or air that are a threat to planetary, human, animal or plant health” is incorrect, unless zero waste is broadened to include all wastes across the full life cycle (as opposed to the narrow focus on solid waste). For example, approximately 42 percent of all domestic greenhouse gas emissions are associated with making, transporting and disposing of materials. Increasing the recovery rate from 33 percent to approximately 95 percent for “municipal solid waste” (and approximately 70 percent for construction and demolition materials) would only reduce these emissions by approximately one seventh. It is a significant reduction, but a far cry from “eliminating all discharges.”

Zero Waste shares some of the same limitations as the Cradle to Cradle philosophy described above. Both suggest that emulating natural cycles and keeping all materials in closed loops (eliminating virgin product use and eliminating waste) are required conditions for sustainability, while giving little attention to all of the intermediate steps in the life cycle. For example, McDonough and Braungart’s compostable upholstery fabric may satisfy Zero Waste principles, while being fundamentally unsustainable. From a design perspective, Zero Waste requires that all products be recoverable. Narrow application of Zero Waste principles elevates recoverability to the principal environmental consideration when designing products. This sometimes leads to unintended (and undesired) results, as recoverable materials may have higher environmental footprints (when viewed across their full life cycle) than non-recoverable materials.

The very language of “zero waste” also places emphasis on waste, or end-of-life management, which is often one of the least impactful phases of the life cycle, for many materials. Emphasizing waste is potentially unhelpful if doing so de-emphasizes the more significant life cycle stages and draws focus away from them. Emphasizing “waste” and “waste avoidance” (zero waste) is also unhelpful if it causes users to lose sight of the differences between prevention, reuse, recycling and composting. As an example of how Zero Waste is easily oversimplified, a major movie studio in California recently shared that as part of its Zero Waste efforts, it has replaced most dishware in its cafeteria with compostable products. The dishware is mixed with food and yard scraps and turned into compost, which the studio applies to its landscapes and provides to employees. While diverting wastes from landfill and appearing to satisfy “zero waste,” this change begs several questions. Would reusables be a better choice? What are the life-cycle impacts of the compostable dishware, relative to alternatives (both reusables and single-serve)? What if the impacts of producing the single-serve compostable dishware are greater than the impacts of producing other single-serve alternatives? Does the dishware actually contribute any value to the compost and, if so, what is the environmental value of that compost? Given all the resources required to make this product (not only materials, but also energy), using it once and converting it to compost results in those resources being largely (if not totally) lost: a potential waste of resources, even if called “zero waste.”

**Natural Step**

Summary: The Natural Step is derived from the work of Dr. Karl-Henrik Robèrt, a Swedish cancer doctor who became interested in issues of sustainability, and attempted to derive the basic conditions of society that would lead to the continued well-being of human life and the environment. He derived what he called the four system conditions of sustainability, which has been rewritten by the Natural Step non-profit organization to be more understandable to non-scientists as the Four Conditions of Sustainability*:

| **The Four System Conditions...** | **. . . Reworded as The Four Principles of Sustainability** |
|---|---|
| In a sustainable society, nature is not subject to systematically increasing: | To become a sustainable society we must: |
| 1. concentrations of substances extracted from the earth's crust | 1. eliminate our contribution to the progressive buildup of substances extracted from the Earth's crust (for example, heavy metals and fossil fuels) |
| 2. concentrations of substances produced by society | 2. eliminate our contribution to the progressive buildup of chemicals and compounds produced by society (for example, dioxins, PCBs and DDT ) |
| 3. degradation by physical means | 3. eliminate our contribution to the progressive physical degradation and destruction of nature and natural processes (for example, over harvesting forests and paving over critical wildlife habitat); and |
| 4. and, in that society, people are not subject to conditions that systemically undermine their capacity to meet their needs | 4. eliminate our contribution to conditions that undermine people’s capacity to meet their basic human needs (for example, unsafe working conditions and not enough pay to live on). |

*Source: http://www.naturalstep.org/~natural/the-system-conditions

In addition to the system conditions, The Natural Step has developed a process for businesses and others to use in trying to reach goals based on these system conditions. That process, of determining future end goals to be achieved that are consistent with the system conditions and then backcasting to the present in order to determine the path that will lead to those goals, is what DEQ is using to develop the Vision for Materials Management, which in turn will provide a foundation for updating the State’s solid waste management plan.

Advantages: The Natural Step is comprehensive in addressing all of the different measures of environmental impacts (see measures of environmental impacts paper). If the four system conditions are truly being met, then:

- There would not be systematic removal of petroleum and other non-renewable resources from the earth's crust.
- There would not be a continued buildup of greenhouse gases.
- There would not be excessive use of fresh water leading to fresh water depletion.
- There would not be a continued buildup of nitrates and phosphates in our waterways leading to eutrophication.
- There would not be acid gases released to the atmosphere leading to acid rain.
- Soil fertility would not be systematically degraded.
- Toxins would not systematically enter the environment at levels that could affect human health or damage the ecosystem.

The Natural Step is also advantageous in that it clearly addresses materials and their impacts in all phases of their lifestyle, from manufacture through use through end-of-life management.

The Natural Step is accepted by several prominent Oregon businesses, including Nike, The Collins Companies, Ashforth Pacific, and SERA Architects.

Limitations: The Natural Step process provides a good framework for setting goals and then working on developing a path to achieve those goals, but it doesn't on its own provide a quantitative methodology by which the four system conditions can be achieved. Very substantial additional work will be needed to determine what sort of actions could quantitatively lead to the system conditions being achieved. For example, complicated modeling might be necessary to determine impacts that the manufacture or consumption on material might have on net quantities of materials extracted from the earth's crust, the concentrations of chemicals in society, or the degradation of natural resources. The Natural Step does not directly provide any guidance on how these impacts should be modeled, but only specifies the end result that should be achieved.

Achieving the four system conditions can seem overwhelming. The late industrialist Ray Anderson, who used the Natural Step at the carpet company Interface, characterized the system conditions as akin to “the summit of Mt. Sustainability” and described them as being so far away as to seem almost unachievable. Achieving the system conditions also depends on changes by others. Once this is understood, however, the system conditions can serve to provide bearings, so that one at least knows that changes represent progress in the right general direction.

**Ecological Footprint**

Summary: The concept of "Ecological Footprints" is to convert consumption-based environmental impacts into a single variable: the amount of land required to live sustainably at that level of consumption. A person's ecological footprint is equal to the land (and water) needed to produce the food and goods that the person consumes, plus the land needed to absorb the carbon dioxide that the person produces, including carbon dioxide generated from producing the food and goods consumed and from all other uses of energy, such as transportation and home heating.

Under Ecological Footprint accounting rules, all acres of land are not the same. Each acre is weighted by the average productivity for that class of land. Thus, the average acre of highly productive cropland is worth 2.51 global acres, while the average acre of forest is worth 1.26 global acres, grazing land is worth 0.46 global acres, and marine and inland waters are worth 0.37 global acres.

Advantages: One of the great advantages of the Ecological Footprint is that it is quantitative, and footprint needs can be calculated for individual activities and categories of consumption. This allows people to calculate their own footprint, and to determine how their footprint would change based on changing practices and changing levels of consumption. Using data from the United Nations and other sources, it is also possible to calculate the environmental footprint of whole countries, and compare that to the amount of productive land in that country. Because the ecological footprint is based on consumption, a nation's ecological footprint will take into account the products that it imports (which add to its footprint) as well as those exported (which subtract from its footprint).

Looking at the Ecological Footprint of countries on a per-capita basis provides some useful comparisons, as well as methods that can be used to help bring about environmental equity between rich and poor countries. Under Ecological Footprint accounting for 2010, the average United States citizen would need 19.8 acres to live sustainably. In contrast, the average Cuban would need only 4.6 acres, and the average Haitian would need only 1.7 acres. Overall, the average world citizen would need 6.7 acres.

Unfortunately the average amount of land available per person in the whole world is only 4.4 acres – and this is if all land and water is devoted solely to satisfying human demands, with no land or water set aside explicitly for other species. What this means is that the peoples of the world, in total, are not living sustainably, and there is not enough land to sustainably provide us with all of the resources we consume and absorb all of the carbon dioxide that we emit. Thus, resources (forests, fisheries, topsoil, etc.) are being harvested at unsustainable rates and carbon dioxide continues to build up in the atmosphere. The ecological footprint community refers to this as "overshoot," meaning the world is drawing down its ecological capital by using more resources than it can sustain.

The concept of Ecological Footprint draws several analogies from financial accounting and personal finance. Nature provides humans with resources (wood, fish, absorption of pollution, etc.) which is akin to interest or dividends that we “earn” as a result of the “assets” of a healthy environment. Societies that require more biocapacity than exists are analogous to a household that spends more money than it earns. In the case of Ecological Footprint, this requires liquidating natural assets (degrading lands, depleting fisheries, etc.), which in turn means that fewer assets are available to provide the “interest” that human society depends on. While developers of the Ecological Footprint concept (the Global Footprint Network) have long used these financial concepts as analogies, in recent years they have begun relating Ecological Footprint directly to community and national economies. Recent work has focused on making the case that economic stability and competitiveness are increasingly dependent on managing (and reducing) these ecological deficits. In a resource-scarce world, being heavily dependent on resources is harmful to your economy.

In all, the Ecological Footprint is a powerful intuitive measure that dramatizes the current impacts of consumption and illustrates the significant differences between different countries and populations in consumption patterns.

Limitations: There are significant problems with using the Ecological Footprint as a sole measure of environmental impact. It does not take into account many important environmental factors. Toxins, water use, nitrogen use and eutrophication, nuclear power hazards, air pollutants – none of these are included in Ecological Footprint calculations. Even potent greenhouse gases such as methane and nitrous oxide are not accounted for, since the footprint only accounts for carbon dioxide directly.

Another issue is that Ecological Footprint methodology does not properly account for absorption of carbon dioxide by forests – it underestimates the land required. The methodology looks at the amount of carbon being absorbed by a growing forest each year, and uses that figure to calculate how much forest land would be needed to absorb the carbon dioxide produced by the burning of fossil fuel. The difficulty with this method is that it only works while the forest is actively growing, but does not take into account that the trees eventually die, decompose and return that carbon to the atmosphere. For a fully mature climax forest, the true rate of carbon sequestration is the geological rate at which organic carbon from the forest is eventually turned into fossil fuel – not the current rate of growth of the living trees. An alternative method of accounting for carbon – by estimating the land required to grow biofuels that could be used to replace the fossil fuel – gives results that are slightly more land-intensive than the Ecological Footprint method of forest absorption for dealing with carbon.

**Sustainable Packaging Coalition’s “Definition of Sustainable Packaging”**

Summary: The Sustainable Packaging Coalition is an industry working group with the mission “to use thorough research and science-based approaches to help advance and communicate a positive, robust environmental vision for packaging and to support innovative, functional packaging materials and systems that promote economic and environmental health.” One of the coalition’s first projects was to develop a consensus-based definition of “sustainable packaging.”

According to the coalition, “this definition represents an important first step in articulating a common understanding of the term ‘sustainable packaging.’ It provides a common vision and a framework for understanding activities directed toward improving packaging, and continues to inform the future vision of the coalition and its individual member-companies. This definition has been widely adopted throughout the packaging industry.”

While packaging represents only a subset of materials, this definition is provided as an example and could, in theory, be extended to other (non-packaging) materials.

The definition is provided in two formats: summary and detailed.  The summary definition reads as follows:

“Sustainable packaging:

- Is beneficial, safe & healthy for individuals and communities throughout its life cycle;
- Meets market criteria for both performance and cost;
- Is sourced, manufactured, transported and recycled using renewable energy;
- Optimizes the use of renewable or recycled source materials;
- Is manufactured using clean production technologies and best practices;
- Is made from materials healthy in all probable end of life scenarios;
- Is physically designed to optimize materials and energy;
- Is effectively recovered and utilized in biological and/or industrial closed loop cycles.”

The longer definition is available at http://sustainablepackaging.org/uploads/Documents/Definition%20of%20Sustainable%20Packaging.pdf.

Advantages: The definition addresses all three of the proverbial elements of sustainability: environment, society and economy. It is not limited solely to environmental considerations.

On the environmental front, the definition sets forth a series of conditions, but while some are absolutes, others are relative. For example, all packaging must be “sourced, manufactured, transported and recycled using renewable energy,” “manufactured using clean production technologies,” “made from materials healthy in all probable end of life scenarios” and “effectively recovered . . .” These represent objective, absolute criteria. In contrast, use of renewable or recycled source materials must be “optimized,” as must materials and energy during the design process. Use of the term “optimized” provides some flexibility, recognizing that use of renewable or recycled source materials, as well as other materials and energy, may influence the other criteria. Put differently, the definition doesn’t mandate minimal use of materials (as in some cases, more materials might be better) and it doesn’t mandate total avoidance of nonrenewable or virgin source materials (as avoiding them altogether might introduce other trade-offs). Trade-offs between the criteria abound, and the mix of absolutes and relatives provides some guidance and flexibility to businesses trying to apply these criteria.

In practice, the coalition’s definition has had a humbling effect on some companies that produce consumer goods. It is now commonly acknowledged in packaging circles that “no packaging is currently sustainable.” This is in contrast to earlier years, when some companies would claim sustainability for having merely reducing packaging weight or increasing recycled content. The definition has set a relatively high bar, one that is hopefully encouraging greater innovation, creativity and change.

Limitations: A package that meets all of the conditions might still not be sustainable. For example, a package might use only renewable energy throughout its life cycle, but if the renewable energy is biologically-derived and competes with food supplies so that food prices and hunger increase, social needs are not being met, and if significant pollution is produced across the life cycle, the energy would not be environmentally sustainable either.

### Internalizing Externalities/Least-Cost Planning

Summary: Internalizing externalities and least-cost planning are two separate concepts, but they are sometimes applied together. For this reason, they are described here together.

Externalities are the costs to society that are not reflected in the price of goods and services. Pollution, in its various forms, is a commonly-cited example of an externality. For example, when industry pollutes for “free,” society pays the resulting costs (through decreased resource productivity, health impacts, disruptions related to climate change, etc.). In conventional economic theory, the existence of externalities means that resources are not allocated efficiently. This inefficient allocation of resources (set by the juncture of the supply and demand curves based on prices that don’t reflect true costs) means that society in total pays more, in total, than it would if resources were allocated more efficiently. The most efficient allocation of resources requires that all costs be reflected in prices, or put differently, that all externalities have been internalized.

In the case of pollution and other environmental impacts, internalizing externalities would raise costs to anyone who pollutes or otherwise imposes environmental costs on society. As the true environmental costs became reflected in prices, both consumers and producers would have strong financial incentives to find ways to reduce these costs.

Least-cost planning extends this concept to decision-making, including policymaking: policy (or other) options are evaluated for their costs, and the options with the lowest costs are implemented first.

Combining these two concepts, even if externalities weren’t actually internalized, policymakers could make decisions using least-cost planning principles, acting *as if* the prices actually reflected true costs. For example, DEQ currently allows permittees to “recycle” source-separated glass by using it as aggregate in the construction of temporary landfill roads. In part, this practice is based on demonstration that other recycling options would cost the hauler more money. This represents a least-cost planning approach, but without accounting for externalities. Doing so would require adding to the costs of these alternatives (landfill roadbase vs. other alternatives) the costs to society associated with pollution. Decisions would then be made based on full social costs, not just cost to the garbage hauler (or rate-payer). The lower-cost options, when full social costs are taken into consideration, might be different.

Of note, the Oregon Global Warming Commission’s Interim Roadmap to 2020 recommends that the cost of greenhouse gas emissions be included in policy-making considerations. Implementing this recommendation would be an example of internalizing externalities.

Advantages: Oregon has precedent for using least-cost planning using full social costs, at least on a limited scale. The Northwest Power and Conservation Council uses least-cost planning principles, and inclusion of some social/environmental costs in these efforts is widely credited for the region’s significant investment in energy conservation.

The idea of internalizing externalities is widely accepted by economists of all stripes and political persuasions, as it leads to a more efficient allocation of resources. It has also been embraced by some in the environmental community as a way of leading to better environmental outcomes.

Even if externalities can’t be actually internalized, the process of evaluating these costs also yields potentially powerful information about how and where environmental impacts occur.

Limitations: Not all environmental impacts are local, and so “society” may have to be defined broadly to include all of humankind and the entire earth. This begs a host of ethical and practical questions about what to include and how to value its costs. In addition, to the extent that policy or voluntary actions result in externalities actually being internalized by some players but not all, it can create an unlevel playing field where some producers’ prices account for these costs, while their competitors’ – outside of the policy sphere – do not.

Internalizing externalities – or even estimating what these externalities might be – can require extensive, expensive, time-consuming and controversial analysis. It requires knowing both life cycle emissions (environmental impacts), and also agreeing on economic values by which these impacts should be “monetized” (expressed in terms of dollars). Different modeling approaches can lead to significantly different results. For example, a recent report by the Stockholm Environment Institute’s U.S. Center concludes:

> “The ‘social cost of carbon’ – a calculation of the damage caused by each ton of carbon dioxide ($CO_2$) emitted into the atmosphere – is a key factor in U.S. environmental regulation, used to set the optimal stringency level for a wide range of policies. Since early 2010, the U.S. government has used a social cost of carbon estimate, developed by an interagency group, of $21 per ton of $CO_2$. But that number . . . is based on fundamentally flawed methodologies and grossly understates the potential impact and uncertainty of climate change. Making small adjustment to the models to reflect these factors lead to values as high as $893 per ton in 2010 and $1,550 in 2050.”

In addition, some object to the principle of monetizing environmental and health impacts, particularly when it requires making assumptions about the financial value of human life or other intangibles. The full social and environmental costs of materials are not knowable, and reasonable people may disagree regarding the magnitude of these costs. But the lack of absolute knowledge is a poor excuse for inaction – even including some externalities in decision-making will lead to a more efficient allocation of resources (and presumably, a reduction in environmental damage), when compared to the status quo.

Perhaps more fundamentally, it is important to note that even if all externalities were internalized, society might still not be sustainable. Rather, we would arrive at a point where total costs (hard transaction costs as well as social costs, in sum) were minimized. This is not the same as actual sustainability.

## Conclusion

Each of the frameworks presented above offer both advantages and disadvantages; none of them appear to be ideal. Options include working within these existing frameworks, trying to improve upon them, or even trying to combine them into a hybrid “best of all worlds” framework.

Defining “sustainability” is challenging, and there are few (if any) examples we can readily point to of truly sustainable materials used in modern commerce, at least not in the quantities used today. Sustainability is also complex. Definitions based on a single criteria (such as “minimizing solid waste disposal”), while easy to communicate, increase the likelihood of unintended consequences, and are probably the least useful in defining true sustainability. Sustainable materials don’t exist in a vacuum; for materials to be sustainable, related systems such as transportation and energy also have to be sustainable. These larger changes are far outside the immediate influence of DEQ’s Solid Waste Program, but it is important to note them nonetheless.

Sustainability professionals often describe the path to sustainability using the analogy of a journey to a distant destination. On any long journey, even if the route to the final destination is not definitively mapped out, it is helpful to know the right general direction. These definitions of sustainable materials and sustainable materials management offer several options that might help to provide that kind of direction.