



REPLACE - THE MISSING "R" IN THE WASTE MANAGEMENT HIERARCHY

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Introduction

Over the past 40 years, communities, environmental groups, and other concerned individuals and organizations have adopted the waste battle cry of “Reduce, Reuse, Recycle!” These 3 R’s of **Reduce**, **Reuse**, and **Recycle** are often described as the Waste Hierarchy.¹ This waste hierarchy has taken many forms over the years, but the basic concept has remained the cornerstone of most waste minimization and management strategies. The aim of the waste hierarchy is to capture the maximum amount of benefit from products and to generate the minimum amount of waste.² The hierarchy is a classification of waste management options in order of their environmental impact, typically from ‘most preferred’ (most environmentally sound) to ‘least preferred’ (least environmentally sound).

As is the reality of most environmental issues, waste management solutions are not necessarily as simple as they may appear, and simplistic approaches both neglect the complex realities of environmental issues and risk adoption of behaviors that aggravate rather than address material use problems. Consider the recycle emphasis as a case in point. Although the recycling of plastic bottles has increased dramatically over the last twenty years, the absolute number of plastic water bottles in the waste stream has increased even more significantly as people have increasingly purchased water in these “recyclable” containers. Thus, more resources are used to manufacture new bottles. Then, just because a bottle is recyclable doesn’t mean it is actually recycled; nor does it mean that it is recycled back into the same kind of bottle that you started with (which would reduce the demand for new plastic).

For discussion purposes this report recommends that a 4th R – **Replace** – be added to the waste management hierarchy. Including “replace” can help guide the fundamental material selection process and recognize the importance of renewable, naturally recycling biomaterials as a priority over virgin materials. This fourth “R” suggests that wherever possible people should replace the use of finite, energy-intensive materials with renewable, low-energy biomaterials. Thus the modified hierarchy would be Reduce, Replace, Reuse, and Recycle.³



¹ Some authors and/or organizations have divided the hierarchy into 5 or 6 steps or more (in many cases renaming or further dividing the R’s into sub-categories including reduce, refrain, reuse, recycle, recover, rebuy, replenish, repair and rethink). None specifically addresses, however, the core concept of this report, which is to add “Replace” to the hierarchy.

² See <http://whengreengo3r.blogspot.com/2008/11/what-is-3-r.html>.

³ The hierarchy, as depicted in the above graphic, is not so much a sequence of events but rather a comparison of choices. For example, if the only choice one is faced with is choosing between a product made from either a renewable or non-renewable resource (sustainably harvested trees vs. virgin steel, for example), the renewable

Background

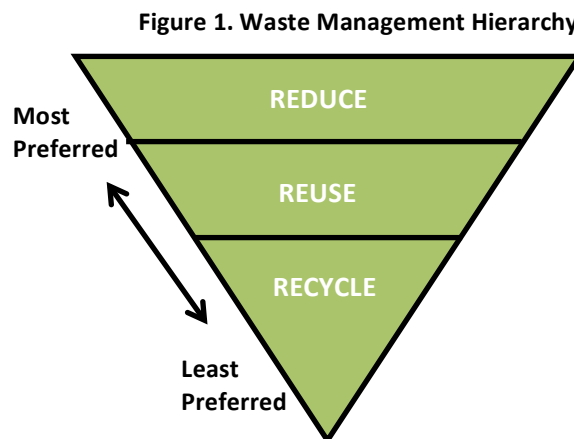
In the late 1960s to early 1970s, people sought a simple mantra to classify waste management options in terms of their positive impact on the environment. Although its exact origin is unclear, the waste hierarchy of Reduce, Reuse, and Recycle has guided environmentalists in the United States since the first Earth Day in 1970. Over the past forty years, people have proposed a number of additional “R’s,” such as reconsidering the entire waste management system (“Rethink”), the importance of recycling through compost (“Rot”), or simply refusing to buy things that generate waste (“Refuse”). To date, however, the simplicity of the 3 R’s has stood the test of time in the U.S., and it remains the mantra most Americans recognize.

Under the 2008/98/EC Waste Framework Directive, Europe has adopted a five-part waste hierarchy: *Prevention, Preparing for Re-use, Recycling, Recovery* (including for energy) and *Disposal*.⁴ Included in this Directive are targets for recovery and recycling and the introduction of concepts of “extended producer responsibility” and the “polluter pays” principle. Although this hierarchy doesn’t have the alliterative ring of the 3R’s, it does have the advantage of being more clearly descriptive and recognizing the more complex nature of waste that simplistic approaches neglect. We suggest it is time to consider a more comprehensive approach in the U.S. as well.

The 3 R’s

Reduce

Reduce is the first choice in the hierarchy of integrative resource/waste management. Reduce can be translated into the simple phrase ‘buy less and use less.’ In other words, the best way to deal with trash is not to have any. The idea behind the Reduce category is to get people to think twice about whether or not they need something before they buy or use it and to seek alternative, creative ways to meet needs without increasing consumption. The ultimate goal of Reduce is to decrease the volume and toxicity of wastes each person



resource gets the nod (all other things being equal), and Replace would likely be placed second in the hierarchy. However, if the entire array of choices is available to an individual (think paper vs. plastic bags at the grocery store) then using virgin materials is likely the last option a shopper considers (no bag – 1st option; reused bag – 2nd option; recycled bag – 3rd option; replace bag made from a renewable resource – 4th option).

⁴ <http://ec.europa.eu/environment/waste/framework/index.htm>

generates in the course of daily life. It also means that by choosing to reduce consumption by buying and using less as the first priority, valuable resources like water and energy (which would otherwise go into the production of materials) are conserved.

Recommendations for reducing trash include avoiding unnecessary packaging, avoiding items designed to be used only once, and using durable, reusable products. For example, many people have moved beyond the “paper or plastic” question at the grocery store and now bring their own durable cloth bags in which to carry home their purchases. Some stores encourage this behavior by selling these low cost cloth bags and by providing a small discount at checkout for shoppers who provide their own bags. Communities in at least six different states have banned the use of plastic shopping bags or required stores to charge a fee for them, thereby encouraging an overall reduction in the use of disposable shopping bags.⁵

Reuse

Reuse is the second choice in the waste management hierarchy. Reuse is concerned with extending the life cycle of a material or product, with minimal or no conversion of form. Reuse can be defined as simply finding more (and/or different) ways to use an item. Reusing items can save energy and money. Purchasing and using durable items with long lives also fits into this strategy. The reuse of housing and furniture are major examples of this approach as are high-value components of housing such as flooring, cabinets, and certain fixtures. Other examples include the reuse of cars, auto parts, books, jars, packing materials and containers, and donating usable goods such as toys, clothing, and eyeglasses to charity.

Recycle

Recycling is often the most recognized option of the three R’s. For many materials, curbside collection makes recycling easy and convenient. Recycling collection can be done at home (e.g., milk jugs and soda cans), at work (e.g., cardboard and office paper), and on the go (e.g., plastic and paper recycling at airports, campsites, and on city streets). In certain instances, recycling is so easy and convenient that it can overshadow the “reduce” and “reuse” messages, as in the water bottle example above.

In essence, recycling takes discarded items and separates them into materials that can be re-manufactured into new products. In essence, recycling involves reuse of a material in a significantly modified form. There are two types of recycling – “*upcycling*,” which refers to the conversion of low-value materials into high-value products, and “*downcycling*,” which refers to the conversion of high-value products into low-value materials. In general, upcycling is more desirable, to the extent that it is more likely to result in a long-lived product and thereby keep the material out of the waste stream for a longer period of time. However, both upcycling and downcycling address the primary objective of minimizing waste disposal in landfills.

⁵ <http://www.bloomberg.com/news/2013-06-26/plastic-shopping-bags-may-go-the-way-of-lead-paint.html>

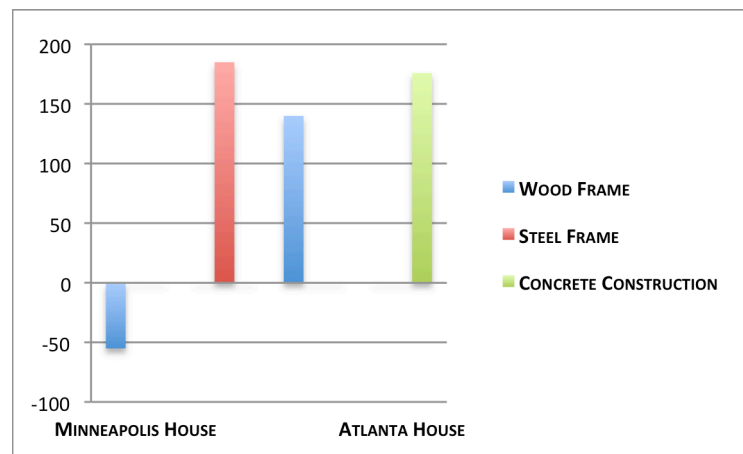
In the U.S., composting is increasingly being included in the category of recycling. This inclusion creates important opportunities to address organic and biodegradable waste (e.g., food, plants, yard waste, etc). Some advocates for including composting as a form of recycling view it as nature's way of recycling. Also, other types of waste recovery, such as energy recovery, are included in the broad category of recycling by recycling experts (although the EPA does not recognize energy recovery as a form of recycling). To the extent that a wide range of material recovery behaviors are included under the umbrella of recycling, new and innovative approaches can emerge to address collection, handling, and utilization of diverse waste materials.

The Missing “R” – Replace

The waste management hierarchy of reduce, reuse, and recycle is entrenched in the public's mind and has the advantage of making sense to most people. What is often missing, however, is the distinction between renewable and non-renewable materials and products. The waste management hierarchy, as portrayed by the 3 R's, does not explicitly incorporate replacement as a strategy.⁶ And where replacement is implied as a strategy, little or no discussion centers on the renewability of the materials or products. Moving forward, the replacement of non-renewable materials and products with renewable alternatives is an essential component of waste management.

The U.S.-based Consortium for Research on Renewable Industrial Materials (CORRIM), for example, has published numerous reports over the past decade comparing (via life cycle analyses) renewable versus non-renewable materials. CORRIM reports such as Perez-Garcia et al. (2005) (see sidebar) have consistently shown that building materials made from wood products (i.e., produced from renewable materials) have substantially lower environmental impacts than building materials produced from non-renewable materials (such as steel, concrete, aluminum, brick, and plastic).^{7,8}

Figure 2. Net carbon dioxide emissions (metric tons) for two home design comparisons



Source: Perez-Garcia et al. (2005)

⁶ The strategy of “Rethink” comes closest to implying that “Replace” needs to be considered in waste management strategies. For example, some authors/organizations argue that “Rethink” is the most important of the strategies. Examples include rethinking the use of conventional fuels to natural gas (as a substitute), or rethinking how electricity is generated. See: <http://www.stonybrook.edu/com/recycling/4rs.shtml>.

⁷ <http://www.corrim.org/pubs/reports/2005/phase1/MainReport&ExecSum.pdf>.

The same differences exist in products other than building materials. Production and use of renewable, bio-based products almost always result in lower (and often much lower) environmental impacts than products made of non-renewable materials.⁹

In short, the type of materials used – renewable versus non-renewable – plays an important role in the waste hierarchy. Given that part of the aim of the waste hierarchy is to capture the maximum amount of benefit from products, inserting a “Replace” strategy into the existing 3 R’s draws attention to the potential for renewable materials to increase the environmental benefits of product use.

A Proposed New Hierarchy

A new waste management hierarchy is proposed in Figure 3. The new hierarchy still begins with the message of “Reduce”. In other words, as a society, reducing the stuff we use is the number one goal – whether the ‘stuff’ is made from renewable or non-renewable resources.

Sidebar 1. Environmental Impacts of House Construction

Perez-Garcia et al. (2005) compared designs for residential construction in Minneapolis (wood-frame house vs. steel-frame house) and Atlanta (wood-frame house vs. concrete-construction house). In the Minneapolis case, they found that wood had *better* (less risk) environmental performance indices than steel in embodied energy (17%), global warming potential (26%), air emissions (14%), and water emissions (312%). Only solid waste (from wood) had a worse index than steel (0.9% difference). When common elements in the structure were factored out in the analysis, so as to directly focus on environmental impacts of various construction materials, the differences in impact became much larger. For instance, in comparing wood to steel for floor and roof assemblies, environmental risks associated with wood were found to be 67%, 157%, 85%, and 312% lower with respect to embodied energy, global warming potential, emissions to air, and emissions to water, respectively.

When comparing wood to concrete in the Atlanta example, wood had *better* (less risk) environmental performance indices than concrete in embodied energy (16%), global warming potential (31%), air emissions (23%), and solid waste (51%). (They found no differences in water emissions.)

The same study reported that ‘cradle to grave’ net carbon emissions, or avoided carbon emissions (in metric tons), were 55 *avoided* tons for the Minneapolis wood-frame house compared to a net *source* of 185 tons for the steel-frame house (for a difference of 240 tons). Net emissions for the Atlanta wood-frame house were 140 tons versus 176 tons for the concrete-construction house (Figure 2).*

In addition to the advantages of wood over steel or concrete in terms of environmental impacts, only one of these three materials is renewable – wood.

* *Carbon dioxide emissions included fossil fuels in manufacturing, construction and demolition, biofuel, maintenance, heating and cooling, forest sequestration and wood product storage. Also, the increase in net carbon emissions for the Atlanta wood-frame house is due primarily to the difference in quantity of wood used between Minneapolis (6,634 kg) and Atlanta (3,093 kg); carbon sequestration in Southern pine forests is also vastly different due to shorter rotations.*

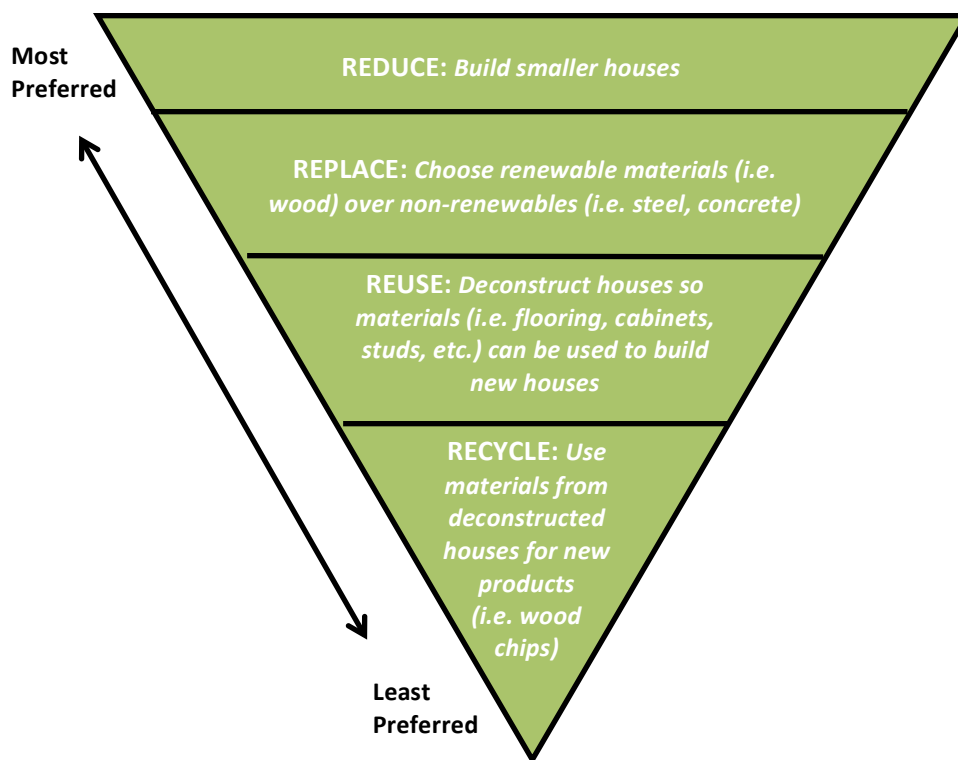
⁸ Other studies have shown that the ‘origin’ of renewable materials is also important in determining environmental impacts. Gan (2013) found that producing wood products in the U.S. rather than importing from China or Brazil reduces greenhouse gas emissions from the world’s wood products sector and helps conserve tropical forests.

⁹ For a discussion of environmental impacts of solid hardwood flooring, and hardwood lumber in southeastern U.S., see the following: http://www.corrim.org/pubs/reports/2010/swst_vol42/79.pdf and http://www.fpl.fs.fed.us/documnts/pdf2012/fpl_2012_bergman001.pdf.

Next, products with high-embodied energy should be “replaced” with products requiring a lower energy to produce. In the case where a new item or material is being considered, “Replace” means choosing renewable materials over non-renewable materials. The strategy of “Replace” is focused on cases where renewable products (such as wood) can replace non-renewable products (such as concrete and steel), resulting in a net environmental benefit. Another way of phrasing this strategy is to use bio-based materials instead of fossil fuel-based materials, especially where the substitution advantage is large.

The new waste management hierarchy still ends with Reuse and Recycle. Whether a product is made from renewable or non-renewable materials, once it has the potential of entering the waste stream, it is still important to reuse or recycle it.

Figure 3. Proposed New Waste Management Hierarchy (and example scenario)



Bottom Line

The waste management hierarchy should include a “replacement” strategy where resources with low embodied energy “replace” resources with high-embodied energy. This is important because the hierarchy is a tool for reducing the environmental impacts of human activities. A replacement strategy tends to favor renewable products such as wood, paper, and other bio-based fibers. Numerous studies have shown that renewable materials have fewer negative impacts on the environment than non-renewable materials.

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