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Sustainable Product Design: Just the Facts

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Contents:

knowledge+research

What is “Green”

Almost everywhere we turn, products are presented as “environmentally friendly”, “green”, or “sustainable”. How do we cut through the green tape to determine what really is a better choice? Perhaps the first thing to do is to get a clear understanding of a couple of terms:

Sustainable: This word is frequently used to describe products, has a very specific meaning and, in almost every case, is misused. Let’s start by looking to the dictionary:

Sustainable - “of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged.”

Merriam Webster Online Dictionary

In the ecological world, this word has a more specialized meaning:

Sustainable - “meeting the needs of the present without compromising the ability of future generations to meet their own needs."

Virtually any product that uses electrical power, energy from natural gas, materials from the earth, or transportation of any kind does not meet this definition as all of these deplete resources and damage the environment.

Green: While evoking images of barefoot children romping through mountain meadows next to a babbling stream and enjoying the benefits of the referenced product, in reality this word means pretty much anything, and therefore almost nothing. (Synonym – environmentally friendly)

So amid such a blizzard of claims of environmentally friendly product attributes, how do we determine what is real and what is greenwash?

While it is very tough to make such a complex topic completely clear there are a few key areas to focus on:

Chemistry

You remember chemistry, right? Usually taught by somewhat socially challenged individuals with a really deep appreciation for starting things on fire, most of us got through this topic by snagging a seat next to a pre-med honor society student and “working with” them for the duration of the semester. We’re not going to go into any real depth here, but the main question is fairly simple: What is this product made out of, and have the materials been assessed for their impact on human and environmental health? It’s not enough to identify the main ingredients. Because bad things come in small packages (think mercury, lead, “mini-me”, that type of stuff), we need to identify all the materials present, down to the 100 parts per million level.

The primary goal is to identify the materials, assess their health impacts and eliminate materials with acutely negative effects on human and environmental health. There is a wide range of potential negative effects:

- Toxic to human and ecological health
- Cancer causing agent
- Reproductive system disruption
- Endocrine system disruption
- Sensitizer
- Mutagenicity (damage to DNA)

A very important chemical characteristic that deserves special attention is that of persistence. Some chemicals, when exposed to nature, are broken down through natural processes into other chemicals. A material which does not readily break down is known as "persistent". The implication is that as a persistent chemical is manufactured and used, it generally finds its way into the natural world through a variety of avenues. Once it is out in the world, this chemical does not break down, and can eventually begin to accumulate in the food chain (a phenomenon known as bio-accumulation). Depending on the chemical, this can have serious long term negative health effects on all of the animals in the food chain, including humans.

Mercury, one of the heavy metals, is a metallic element with a relatively high atomic weight. Formerly known as quicksilver, and anyone who has ever seen this stuff loose will know why, it is one of only two elements that are liquid at room temperature. (Anyone know the other? It's Bromine.) This toxic stuff is emitted from the smokestacks of coal burning electricity generating power plants, and is used in products like televisions, telephones, thermostats, medical devices, fluorescent lights and even the fillings in our teeth. You know those little kids shoes that light up when they walk? They used to use a mercury switch to close the circuit. When these products are thrown away, the mercury can find its way into the food chain. Eventually, it builds up to the point where we can't eat the fish from certain waterways more than once a week. If something isn't safe to eat more than once a week, you have to ask yourself if you want to eat it at all.

A notorious fire retardant, PBDE, falls under this classification. This persistent chemical has been manufactured for 35 years, and is now beginning to accumulate through the food chain and in humans. It is found in the fatty tissue of Great Lakes trout, Orca Whales, and even in the Ringed Seal in the Arctic Circle. And as might be expected, it is now found in increasing concentrations in humans. Recent studies have implicated PBDE's as a health risk for humans, and its use is largely being phased out.

Then there is a whole class of materials that are dangerous in certain situations, but may be safe for use in the application of choice. For example, carbon black is a material commonly used for coloring plastic parts. If carbon black is loose in the air and inhaled by humans, it is known to be a cancer causing agent. When it is tightly bound in a plastic part, it poses no significant risk. Materials such as these, safe within the context of their use, are acceptable.

This is a particularly complex topic within the area of material chemistry and human risk. The risks associated with exposure to a particular chemical depend on the situation. Chemical volatility (the ability to evaporate or off-gas), whether it is dangerous through ingestion, inhalation, or contact with skin, and how tightly bound the chemical is to other materials are all important considerations when evaluating risks. Remember, even oxygen in excessive concentrations is toxic to humans. During the development of the Zody chair, each material was examined to this minute level of detail. Materials which are considered by some to be clear health risks, such as the aforementioned PBDE, PVC, and the hexavalent chromium used in the chrome plating process were designed out of the product. Once a material had been assessed and found to present little to no risk, it was considered acceptable for use. Some materials, such as ABS, a very common plastic, are acceptable for use as long as the process fully "cures" the constituent monomers (acrylonitrile-butadiene-styrene), as the monomers by themselves are toxic to humans.

Energy

Almost all of the energy used in North America comes from burning non-renewable resources such as coal, oil, and natural gas. Not only are these resources non-renewable, there is an unprecedented worldwide scientific consensus that burning these materials is changing the atmosphere, leading to a global climate change.

There is enough nuclear energy generated continuously to provide many times the daily energy consumption of humans. The fusion reactor is located a safe 93,000,000 miles from earth, and is commonly known as the Sun. Solar energy is responsible for many of the natural processes we see around us every day, including the growth of plants, flow of rivers, and wind. For hundreds of years, man has harnessed this energy using water wheel driven grain mills and windmills. Hydrodynamic dams use the flow of a river to drive electricity generation equipment. Solar panels capture the sun's energy directly. Some of the newer approaches which may prove effective harness the energy of tides and ocean currents. On the other hand, nuclear energy generated on earth uses a process known as fission, where Uranium 235 (U235) atoms are split apart into two smaller pieces. The resulting pieces combined weigh less than the original U235 atom, with the mass that is lost being converted into energy according to Einstein's famous equation, $E=mc^2$. (In case you always wondered, and I'm sure you did, this equation means that when you convert mass to energy, as in the case of fission, the energy liberated is equal to the weight of the mass times the speed of light, which is actually a huge number, squared. So it's a lot of energy, even with a little mass.) Uranium processed in this way is an incredible source of energy – a baseball sized chunk is used to power a nuclear aircraft carrier and is roughly equivalent to 1,000,000 gallons of gasoline. However, the by-products of the nuclear fission process are dangerously radioactive and will remain so for centuries, and will require constant vigilance by future generations to store safely. If we refer back to the definition of sustainability, human generated nuclear power clearly is not sustainable.

Coal, a lot of coal, is burned to generate electricity across the U.S..

Coal, while relatively cheap and plentiful, has some issues. Getting a lot of coal out of the ground is not easy, and tends to make a mess of the mountains, trees and animals that happen to be in the way of the equipment needed for extraction. In the old days, the coal companies would dig a mine shaft into the earth to get the coal out. The drive for efficiency has produced a new method of coal mining. In West Virginia, giant machines are brought in and they literally scrape the top off of a mountain, dump the dirt and rock into the valleys, and remove the newly exposed coal. A method that is very effective, but tough on the landscape (and rivers and animals and fish and downstream communities).

Then when the coal gets burned, there are a lot of impacts to consider:

- Carbon dioxide and other greenhouse gases are released.
- Sulfur and nitrogen oxides are released, leading to acid rain.
- Naturally occurring radioactive materials, uranium and thorium, are released into the air.
- Coal power plants release nearly 90,000 pounds of mercury into the air every year in the United States. This mercury ends up in the water and builds up in fish to the point where they can't be eaten. It is a brain toxin that is particularly dangerous for a fetus as it can cross the placental barrier.
- The gases and particulates lead directly to respiratory problems, and are at least partly responsible for a 215% increase in reported asthma cases in the U.S. between 1980 and 1995, and a 20% increase in the annual death rate from asthma during this time.

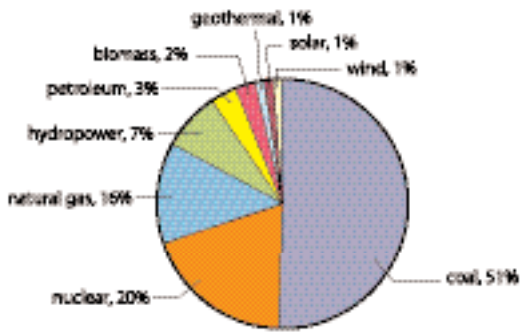
So that's not great. The burning of coal to generate electricity is not sustainable.

The U.S. electrical energy supply comes from several sources, see chart below.

The answer is blowin' in the wind

Wind energy is a promising option that uses large wind turbines to generate electricity which is fed into the electric grid for distribution. As the price of fossil fuels goes up, the cost of wind generated electricity is becoming more and more competitive with traditionally generated electricity. Since the wind power is essentially non-polluting, it is becoming an attractive option for business and residential customers who want to reduce the environmental impact of their operations.

51% coal
20% nuclear
16% natural gas
7% hydropower
3% petroleum
2% biomass
1% geothermal
1% solar
1% wind



Zody is assembled at the Haworth chair plant in Allegan, Michigan using 100% wind power. Not only does this reduce the environmental impact of this green chair, but it also drives demand to support expansion of the wind power infrastructure.

Water, water everywhere

Haworth Corporate Headquarters are located in Michigan, in the midst of the largest fresh water system in the world, comprising 90% of the fresh water in the United States. As a matter of daily life, we don't usually spend much time thinking about whether or not we will have enough water tomorrow. But we certainly should think about water as a precious resource. Even if the quantity of water is assured, the quality is certainly not. Daily human activities, whether personal or commercial, place a heavy burden on the streams, rivers, ponds and lakes. Continuous improvement is needed to reduce this burden.

As part of the Zody development, we examined the water usage at our chair assembly plant. The Haworth plant is a relatively small user of water for the local municipality, and has a minimal impact on the local water treatment plant. Not satisfied with sitting still, however, we are working to eliminate/reduce the phosphate wash system used in this plant to reduce the amount of treatment that our process water needs before being returned to the municipal system.

In a world where much of the population does not have access to a clean, reliable water supply, we have a responsibility to consider local water issues and the impact of our operations on water wherever we do business.

The Big Picture - Life Cycle Analysis

Products can be made from any number of materials and components, each of which has a broad set of environmental impacts over their lifecycle, starting with the extraction of raw materials from the ground to the end of the product's life. Some materials or designs may provide a reduction in one or more impact areas, but an increase in other impact areas. How do we decide which is better?

There is a tool for answering exactly this question. Known as Life Cycle Analysis (LCA), it is a sophisticated method of looking at all of the impacts and adding them up in a way which lets us make decisions on these tradeoffs.

The first step in an LCA is called an inventory analysis. In an inventory analysis, the goal is to examine all the inputs and outputs in a product's life cycle, beginning with what the product is made of, the source of the materials, the operations involved in making those materials, where they go, and all of the inputs and outputs related to those component materials during their lifetime. This process, while extensive and complex, gives the examiner a full picture of the total impact of the product. It is also necessary to include the inputs and outputs during the product's use, such as whether or not the product uses electricity. For products such as automobiles, coffee makers and clothes dryers, which use a lot of energy during their "usage phase", this particular portion of their life can have the most impact.

The next stage of a life cycle analysis is the impact analysis. The environmental impacts identified in the inventory analysis are categorized, sorted, and added up. Through a weighting process, the life cycle analysis will generate a single number that represents how much the environment is affected by the manufacture, use and disposal of the product being examined. This single score method is useful for making broad comparisons of one product design against another. The analyst can look at a number of impact categories such as human toxicity and resource usage in more detail as appropriate.

LCA does a number of things very well. It is ideally suited for doing trade off analysis. A classic case – a manufacturer can source an aluminum part locally from virgin aluminum, or can get it from some distance away made

from recycled aluminum. Does the added impact of shipping the parts from a distant source outweigh the benefits of using recycled aluminum? A well done LCA will be able to quantifiably answer this question.

LCA is a powerful tool for comparing one design concept against another, and sorting out the major environmental impacts (and therefore opportunities for improvement) of a particular product. For example, when Haworth engineers were developing the Zody chair, aluminum was chosen for a number of the larger parts for a number of reasons such as design flexibility, strength, and appearance. It takes quite a bit more energy to extract aluminum from bauxite ore and process it into a usable form than most other common industrial materials. This measure is known as the "embodied energy" of a material. For comparison, the embodied energy of aluminum is 170 MJ / kg, while the embodied energy for steel is 30 MJ / kg.

However, recycling aluminum only takes 3% - 5% of the energy needed to make aluminum from raw materials. It can be recycled indefinitely with no significant degradation of properties. The recycling market and infrastructure for aluminum are very well developed; in fact aluminum is the second most recycled material on earth (after steel). This means that aluminum is a good "technical nutrient". It also means that the positive environmental story of aluminum depends strongly on recycling the material at the end of the product's useful life.

Haworth's LCA of Zody showed that the two biggest impact areas in the manufacture, life and disposal of the chair were:

1) the manufacture of the 16.5 pounds of aluminum for the arms, base, and back uprights
2) the potential of recycling the aluminum parts

It is common in LCA analysis to assume that if a pound of aluminum is recycled instead of sent to a landfill, then that is one pound that doesn't have to be manufactured from raw materials to fill future demand. The avoidance of the impacts that would have occurred from manufacturing that pound from raw materials is "credited" to the recycled pound of aluminum. This recognizes that the least impactful way of supplying aluminum is to divert it from the waste stream. In order to reduce the overall impact of Zody as much as possible, Haworth seating engineers worked with the chair suppliers to specify a very high percentage of recycled content in these aluminum parts. We also established a take back program to ensure that at the end of the chair's useful life, we would return these valuable materials to the recycle stream to be re-used in other products.

The positive impacts of these two steps essentially balanced out the negative impacts of the rest of the manufacturing processes used in making Zody.

LCA is a powerful tool, and we look forward to using it to support wise product design decisions for many years to come.

Looking forward

Being good stewards of the environment has always been a Haworth corporate value. We have always designed products with the environment in mind and will be using what we have learned in developing Zody to guide development of future products.

Materials are being examined more closely than ever, and we will continue to shift our material selections towards the safest and most recyclable materials we can get. Our product development process places a continually increasing emphasis on our Design for Environment efforts.

What makes for slightly more work during the development cycle surely pays off in the long run…for all of us.