From Lean to Green: Interface, Inc.

Dave Gustashaw and Robert W. Hall

Sustainability is a word that has become quite common in today's vernacular. In general, it is philosophically defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This quote from Gro Brundtland has become a rallying cry for those concerned with the degradation of environmental quality around the world. Ms. Brundtland recognized that each generation could easily erode the quality of life for future generations.

Interface, Inc. became very interested in this issue 15 years ago when its chairman, Ray Anderson, was introduced to sustainability. Ray's "spear in the chest" awakening made him challenge the very essence of industrial impacts. His logic was that industry could help address the environmental problem because it helped create it.

In Brief

Interface is a well-known leading manufacturer striving for environmental sustainability. The article describes connections between lean practices and environmental sustainability using Interface's accomplishments as examples. Major leaps broaden the view of waste from that which a customer will not pay for to include environmental wastes, and to broaden operational considerations from internal efficiency to their effects on external processes. Mass-energy balance is the primary "new tool" to help with this.

The challenges were many. Could Interface apply this philosophy in a publicly traded corporation? If so, how? Would customers understand it? Would creditors? Would it improve the business or would it fail? This 15-year journey thus far has resulted in a significant improvement that has become the standard of the worldwide sustainable movement. Interface can demonstrably say that the corporation has improved on every aspect of its sustainable objectives, but it still has much further to go to meet them.

Lean and sustainability are conceptually similar. Both seek to maximize first-quality product (or first-pass yield) and margin. This is accomplished through waste and time minimization. In green language, both seek to maximize system boundary efficiency. The difference lies in where this system (or process) boundary is drawn and how, and in how waste is defined. Lean sees waste as non-value added to the customer; green sees waste as extraction and consequential disposal of resources at rates or in forms beyond that which nature can absorb.

The lean boundary is generally defined by a value stream map. It may be short, or it may trace a value-added trail through a total supply chain enterprise. Sustainability goes beyond this to include environmental impact — the inside-to-outside effect. One way to do this is by analyzing the mass and energy flow in a block diagram showing *everything* that enters and leaves the system. Start with a big system boundary, the entire product life cycle. The goal is to maximize financial opportunity while minimizing environmental impact. This broad view opens opportunities beyond traditional thinking.

Lean has always been regarded as performance improvement. Not so with sustainability. However, pursuing sustainability with rigorous engineering analysis based on block flow diagrams not only defines it operationally, it helps boost process and business performance while reducing environmental impact.

The goal of this article is to explain how to use sustainability to improve process performance. It starts with definitions, develops the block flow analysis, and shows measurements. It explains where lean and sustainability are similar and where they are different. It defines terms as it goes because lean and green terminologies differ. Examples from Interface illustrate how and where we improved.

Interface, Inc.

Interface, Inc. is the worldwide leader in the design, production, and sales of modular carpet and a leading manufacturer and marketer of broadloom carpet. Headquartered in Atlanta, GA, Interface has manufacturing locations on four continents and offices in more than 100 countries.

In business for more than 30 years, Interface is recognized as a leader in industrial ecology. With the vision of becoming the world's first environmentally restorative company by 2020, Interface is pioneering management and manufacturing processes that will achieve this goal. Interface, Inc. is publicly traded on NASDAQ (Symbol, IFSIA). The web address is www.interfaceglobal.com.

Our Results – Total Corporation:

Cumulative avoided costs from waste elimination – $372,000,000
Total waste sent to landfills from manufacturing – down 66%
Total energy use – down 45%
Total renewable energy use – 27%
Percent renewable or bio-based materials in products – 25%
Net absolute greenhouse gas emissions – down 82%
Water – down 75% modular, 45% broadloom
Post consumer/industrial diversion from landfill – 133,000,000 lbs.
Safety – 60% reduction in recordable accidents.

You can see Interface measurements with all this data and much more at: www.interfacesustainability.com/metrics

Lean is a Start Toward Green

A concise definition of lean is to eliminate all non-value-added steps in a process. According to Wikipedia, lean is "focused on getting the right things, to the right place, at the right time, in the right quantity to achieve perfect work flow while minimizing waste and being flexible and able to change." Not bad as an encyclopedia definition, but everyone who has tried lean knows that it doesn't work without engaging the workforce, which may be its real number one goal.

However, as environmental engineers think, lean promotes high efficiency within the boundary of the system as defined by a value stream map intent on minimizing non-value added (NVA). Lean promotes resource conservation inside that boundary, which may be the walls of a plant or may extend to supply chains. As bounded by its definition of NVA, lean is a holistic approach.

Many companies that have trodden the lean path have conserved resources in an environmental sense. Through fewer and shorter material moves, compacting space, improving process yields, and so on, they waste less material or energy doing things that really didn't need to be done. If they concentrated on waste as seen by the environment as well as that seen by the customer, they could do much more.

To some, lean is defined as a set of tools: 5S, failsafe, load leveling (or heijunka), visibility systems usually including kanban, cellular production, and including the starter tool, the value stream map (or total system flow chart). The difference between value stream maps and mass-energy balances, shown in Figures 1 and 2, illustrate the difference in thinking.

Converting Sustainability to Action

The early Brundtland definition defined the result desired from sustainability. It didn't identify operational mechanisms to achieve it. Later, three fundamental impacts, social, environmental, and financial (or People, Planet, Profit) evolved to define business objectives using the original Brundtland philosophy. This triple bottom line, which looks very similar to a definition for quality of life, has become a senior management working definition of sustainability.

But this still doesn't get you to operational process improvement. More specific language is required to define that mission. Interface adopted Seven Fronts: eliminate waste, benign emissions, renewable energy, closing the loop, resource efficient transportation, sensitizing stakeholders, and redesign commerce. The first five fronts deal with the environment, the sixth addresses the social context; and the seventh the business model.

These fronts specific to Interface let it define specific improvement areas. Other companies may need a differently worded mission to suit their specific circumstances. Any mission corresponds to the metrics in different sustainability reports. But whatever mission and metrics you choose, make sure they address each of the triple bottom lines.

Instead of explaining each of the Seven Fronts in detail, you can better grasp the logic by which each is addressed by understanding product and process flow through a macro technical lens called the system boundary analysis. This is a thermodynamic view of a system as analyzed by a block flow or life cycle. This thermodynamic view illustrates the differences between lean and green and presents new opportunities for improvement.

The Environment

To some it sounds silly to define the environment. We live in it, right? We know what's going on. We're compliant, isn't that good enough?

No. Too many rules, regulations, and anecdotal explanations are based on economic compromise. To quote Dr. Robert Ayres, "Either way, the economic system is not closely analogous to an ecosystem. Attempts to use ecological concepts in an economic context are sometimes misleading and unjustified." An environmental explanation has to be separated from financial motives, not so much in micro level detail, but rather in concept. Operational sustainability has to explain the movement of mass and energy within and through boundaries.

The macro-environment bounds both society and industry. It constrains all social or industrial actions whether they are extractive or assimilative. Nature has two big problems with industry: extraction of raw material and energy from the environment at rates far exceeding the environment's ability to regenerate them; and assimilation of mass no longer considered useful thrown back into the environment at rates greater than it can absorb when nature can't recognize them as biodegradable. In between industry uses this mass and energy to provide goods and services to society. We only get money for that.

Thus the environment and industry operate for entirely different motives. We consider industry to be efficient and effective if it meets financial goals. Nature is effective and symbiotic. It has no financial goals. Nature reacts to what is done with it or to it. With the help of the sun, it is self-reliant. Symbiotic relationships allow it to regenerate within limits, provide nutrition to many species, and sequester its waste (coal and oil are examples).

Linear, synthetic industrial systems don't do this. They extract, use, and dispose of their raw materials (nutrients). Too few of its discards appear to provide any nutritional value whatsoever back to even the industrial system. Synthetic industrial systems do sequester their waste at a rate consistent with extraction, but in molecular forms that neither the environment nor the industrial system can re-process. Extractive rates deplete natural resources. Assimilative rates degrade environmental quality. Both severely challenge our quality of life.

Our earth is a mass finite system. That's the operating axiom of sustainability.

The transfer of mass from extraction to assimilation is at the very core of sustainable operations. Can we use mass and energy much more efficiently to serve society? Can we make life cycle operations much more symbiotic?

System Boundaries

A system boundary is simply an arbitrary limit for analytical purposes. It can be made large or small to encompass many different types and scopes of analysis. Defining the boundary of a system enables the mass and energy balance most often used to facilitate engineering design at a manufacturing level. The logic is conceptually simple: Everything that goes in must come out in some form, or in quantitative engineering parlance, energy and mass are conserved. In practice, a mass and energy balance is usually less simple.

A macro level analysis of a system boundary around an entire corporation is a different look at a picture bounded by the income statement in the annual report. It explains what we do and what we need to do it with in thermodynamic language, not money, as conceptually shown in Figure 1.

A system boundary drawn around a plant is consistent with the Value Stream Map in Figure 2. The difference is that a mass-energy balance on an entire plant looks at all the physical mass and energy coming in, whether we pay for it or not, and all mass and energy going out, whether we get any money for it or not — just more stuff for the environment to assimilate. In essence, that block flow diagram aggregates all the physical flows in all the flow diagrams (value stream maps) for the plant, plus the thermodynamic flows, which value stream maps rarely show.

Being publicly traded, Interface feels the same financial pressure as every other company. It is in business to do one thing and one thing only, sustainably make first-quality goods at sufficient margins while providing fiduciary responsibility to the shareholders. In order to do this we need

Conceptual Block Flow Diagram for a Mass and Energy Balance

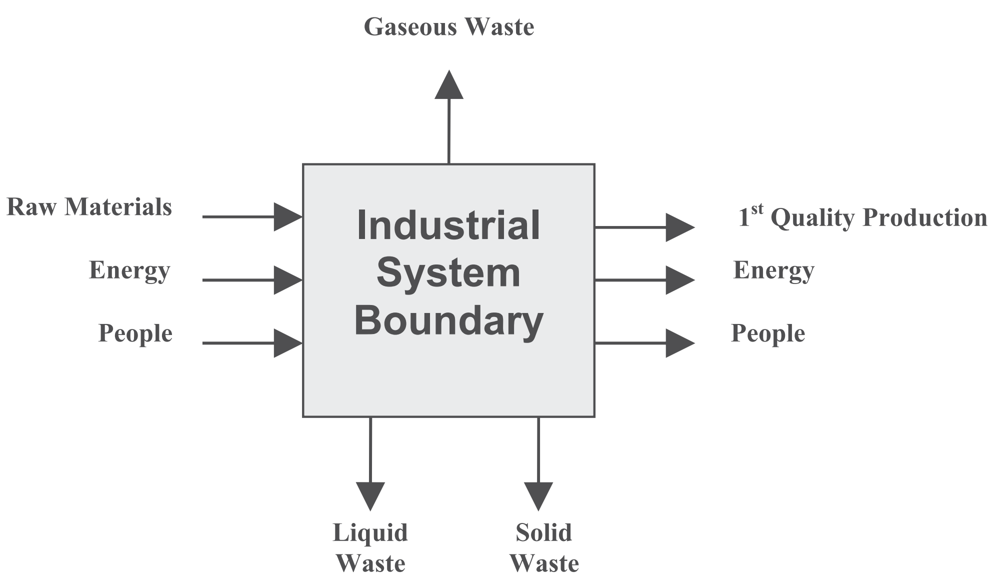

Figure 1. If no chemical reactions or combustion takes place, this is a much like a materials balance plus an energy balance. However, most of the time, a mass-energy balance does have to account for some kind of mass-energy interchange, even if it is only from vapors from a drying operation.

Simplified Value Stream Map with Environmental Issues Added

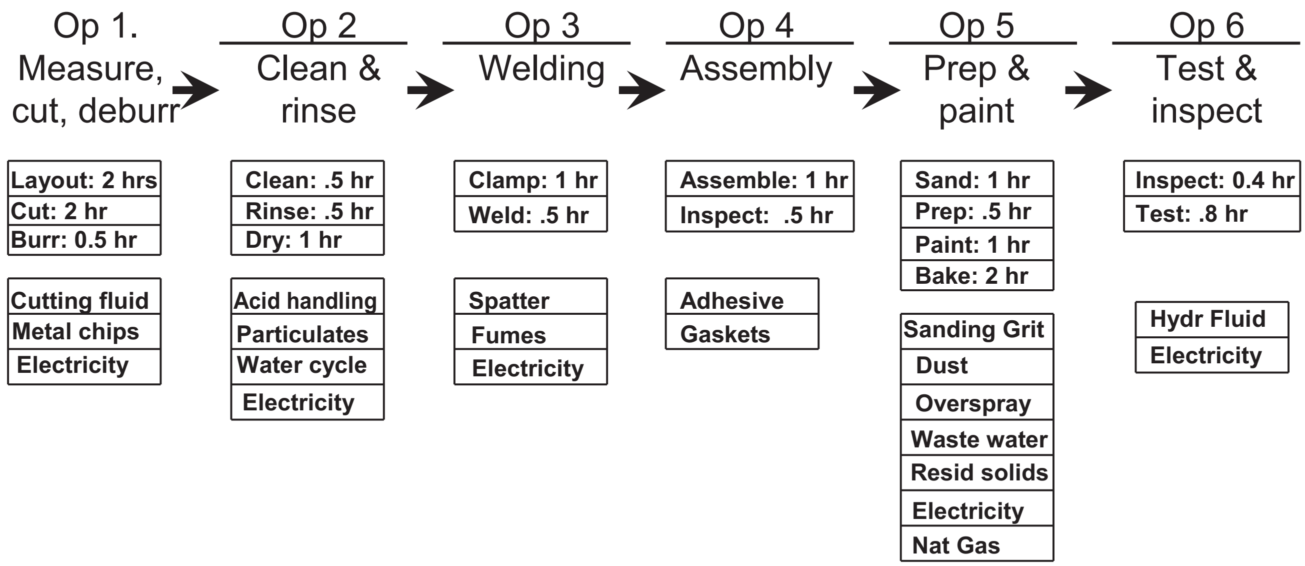

Figure 2. This simplified value stream map (VSM) doesn't even show inventories, but it illustrates going beyond the classic seven wastes by adding notes on environmental wastes and hazards that can be addressed. It shows metal working, not carpet manufacture. The notes on the VSM may prompt some obvious remedial actions, but to really dig in, one needs to create a block flow diagram for each operation and do a quantitative mass-energy balance. Of course, one can do a block diagram and mass-energy balance for all six operations together, or for a bigger system than this, or for some sub-part of any of the six operations.

several inputs: raw materials, energy, and people. These inputs enter the system boundary and have value-added (margin). Some progress through to become output as first-quality finished goods at rates sufficient to satisfy orders. The inputs that don't do that become manufacturing waste. Our thermodynamic objective is to maximize first-quality finished goods using the least amount of input. This is efficiency. Having it as high as possible generates the maximum margin.

But we all know that no bounded system is one hundred percent efficient. As a result, there are three waste streams, gas, liquid, and solid. Each of these is easily quantified for any system. In any bounded system they are undesirable wastes that we were unable to convert into first quality goods for the customer.

A qualitative view of the plant level boundary exists as well. Each of the inputs and outputs are assayed for environmental impact. This assesses the impact of raw materials coming in and waste streams going out, but stops when finished product leaves the door. This system boundary does not cover the total life cycle that includes product use.

Traditional responsibility typically ends at the internal system boundary. That is, an internal system is usually treated as the only entity that matters. I did my job. I made my manufacturing system inside its boundary as efficient and effective as possible. This is the end of my fiduciary responsibility; isn't that good enough?

No, because our internal systems cannot exist on their own. They depend on raw material and energy supplies, customer relationships — and a sustainable environment. However, the environmental impact of everything the company does is the total of all the system boundaries that the company initiates everywhere. This requires block flow analysis of the entire product life cycle.

The Block Flow of a Product Life Cycle

A typical block flow diagram is linear (Figure 3). Simplifying, raw materials are extracted and processed by raw materials manufacturers. Their first quality material is then sold to a converter (like Interface) as a raw material input. The converter then manipulates the raw materials into first quality product which is then sold to a customer. The customer uses the products, then disposes of them at the end of their useful life.

Without quantifying anything, interpreting this block flow diagram is easy. From an environmental view, everything is ultimately wasted. In most instances extraction of raw material exceeds its natural rate of regeneration. Along the way, processing waste is usually dispersed only by complying with regulation, not by assessing environmental impact for that specific case. No residual value, or nutrition, enters the industrial system at the end of the flow diagram. A constant supply of virgin material is required to sustain this model. How long can this continue if we have a finite size to our virgin mass supply?

Why?

Why follow a sustainable model? First, and most important, is concern for the environment. According to World Watch, the population of the planet has been living beyond its means since 1987. Everyone has heard of the dire consequences: climate change, flora and fauna extinction, famine, and so on. Our quality of life is being challenged at an ever-increasing rate. Our businesses could not exist without a healthy, sustainable, environment.

Second, sustainability provides tools — and the incentive — to rethink the way we conduct business. We can analyze new business model configurations and measure the result. They give us the ability to assess our raw materials, energy and waste disposal strategies throughout the block flow diagram. Our goal is a healthy business as well as environment.

By either lean logic or thermodynamic improvement of mass-energy balances, the holistic improvement within a factory system boundary can greatly benefit an existing business model. Materials, energy, rate, flow, etc. are all enhanced to deliver maximum margins. However, considering the block flow of your entire product life cycle is more

Block Flows of Standard End-of-Life Disposal Processes

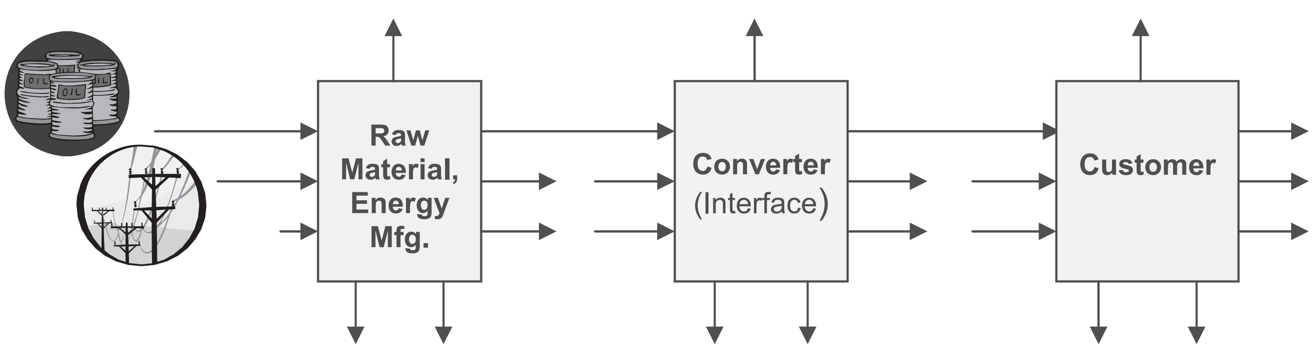

Figure 3. Much raw material and energy sucked into this system spews out as processing waste along the way. Then we can evaluate waste in the customer's use of the product if it consumes material and energy, and finally the waste if the customer throws the product "in the landfill" at the end of useful life.

likely to stir ideas to dramatically change the entire business model. This goes beyond quantitative assessment. It includes qualitative, regenerative, and assimilative assessments inclusive of the entire product life cycle. These assess your overall environmental impact. More important, they uncover unique opportunities for additional cost savings and new supply chain options.

Who cares, you say? You only get paid to improve your manufacturing system, right? And by the way, all this talk of environmental improvement is just going to cost extra money. Well, you might want to reconsider that logic. There is opportunity for your business by thinking beyond its traditional boundary limits. Look closely and creatively and you may see significant savings for both your company and the environment. However, most of us have to start with measurement of the current system and conservation.

Measurement and Conservation

Both Lean and Sustainability start from the same point during the measurement and conservation stage. A system boundary is drawn around the business. In most instances this is the same boundary covered by an income or cost statement. Doing so assures that both process analysis and financial analysis cover the same operations. They are not the same models, but input and output data relate to the same overall entity.

Once this is accomplished, the data can be identified and placed on the system boundary diagram, as in Figure 1. The objective at this point is to establish a baseline mass efficiency and energy effectiveness. We're simply trying to identify the existing business conditions prior to a full blown conservation effort. Since this is a macro level analysis at this point, only the input and output data are required. However, the data must be accurate and complete because the inputs must equal the outputs.

Once this balance is constructed, it's time to start the conservation effort. Jump inside the system boundary, make adjustments to the process, then come back and look at the macro level results. Doing subsystem mass-energy balances will likely identify big-hitters for engineering projects. Environmental notes on value stream maps are more likely to identify a lot of projects that everyone can work on. But all process changes are much like the lean approach, downtime improvement, energy conservation, equipment sizing, process flow, etc. Everything should be evaluated for improvement.

Interface focuses on the mass going through the system first because this is the independent variable. Everything is dependent on mass: size of plant, amount of energy used, the number of people required, and so on. And mass, or the transfer of mass from extraction to assimilation, is the main issue in environmental degradation. In a mass-finite system, this must be kept to a minimum. Only after I'm convinced that Interface has minimized use of mass do I (Dave) go after other opportunities. Interface redesigned carpet to use significantly less mass, a big program in itself.

The conservation effort will increase mass efficiency and decrease the amount of energy per unit made. These values ultimately find a point of maximum efficiency given your overall process configuration. An analogy would be tuning up your car to maximum gas mileage. Once it is operating at maximum efficiency, you simply cannot get more mileage out of that design. To do better, you need a more fuel efficient car. Our businesses act the same way. You can only do so much with existing product designs and business models.

` This is where sustainability and lean (as usually practiced) begin to diverge. Sustainable analysis generally begins where lean leaves off. Suppose that conservation cuts the business' energy use in half. That cost reduction is very helpful, but sustainability doesn't stop there.

Look at a much larger system boundary — the environment — with the business operations nested within it. That opens up new opportunities. Here's an example. At one manufacturing site Interface cut natural gas energy use in half and negotiated the lowest cost per cubic foot possible. This resulted in a very low total cost of natural gas, but the carbon emissions footprint from burning natural gas, even though conserved to the minimum, was still there.

Using sustainable analysis, we looked outside our business boundary to energy opportunities in our communities. Several looked promising. A couple didn't work out, but a third, landfill gas from a local municipal landfill, did. This turned out to be a sustainable triple win. This project voluntarily remediated the air and groundwater contamination from this landfill. Thus the sale of a waste byproduct improved city services for the residents, generated a long-term revenue stream for the city, and offset a large percentage of Interface's entire North American manufacturing carbon footprint. The project was the 2005 United States Environmental Protection Agency Landfill Methane Outreach Program Energy Partner Project of the Year. (Burning methane still puts CO_2 in the air, but methane seeping from a landfill is a worse greenhouse gas; plus burning it avoids burning natural gas, so the EPA encourages this with offset credits.) Incidentally, Interface saved an additional 30 percent on the unit cost of the energy. That's an example of triple bottom-line synergy.

That just begins synergy. Sustainability also analyzes the upstream and downstream system boundaries in the product life cycle, starting with the raw materials suppliers and the customer shown in Figure 3. Interface sought to use the least amount of the most benign materials to manufacture products having the least amount of environmental impact, while improving financial margins and maximum value for our customers.

Interface didn't "own" the entire linear block flow diagram, but it was very influential in the selection of raw materials and controlled the design of products offered to customers. Initially, suppliers were skeptical of unusual requests for recycled or biodegradable materials. Now they have joined the Interface journey. And fortunately, customers supported Interface and believed us when we said, "less is more." This began to change the mindset and approach of the entire industry. As Interface's processes became more efficient and effective, business improved dramatically.

But Interface still had a linear system; virgin material in; used carpet to the landfill. Even though it was internally more efficient and effective it was not sustainable because the life cycle still created waste. Whatever is extracted must ultimately be assimilated. In order to be sustainable, we have to slow down the use of mass and energy to a point that we no longer "compromise future generations to meet their needs."

In order to accomplish that goal, we went back to the issue of mass again, considering how to make it more like nature's way of being effective by being symbiotic. Nature's "waste" is used for many different things. Could Interface make its entire product life cycle more symbiotic? The answer turned out to be yes.

We focused on changing the linear block flow to one that returned our post-consumer waste for reprocessing into new products. We closed the loop (Figure 4).

Interface has now been operating by this block flow diagram in Figure 4 for several years. This recycled mass system significantly reduces the rate of virgin mass extraction and assimilation. The business benefit is that our materials costs have become less volatile because we are now our own supply chain as well as a supply chain to our supply chain! It does get confusing sometimes, but the end result has been much better for our business, our customers, and the environment. Virgin materials cost might shoot to the moon. Ours won't if we keep re-using the same stuff!

This life cycle is consistent with a blended motive of industry and nature. Industry is efficient and effective because of our fiduciary responsibility to our shareholders. Nature, on the other hand, is effective and symbiotic. It has no financial motive. This life cycle combines these two motives to become efficient, effective, and symbiotic. This approach gives us the flexibility to improve our business and environment at the same time.

Closing the Life-Cycle Loop from Customer Back to the Process

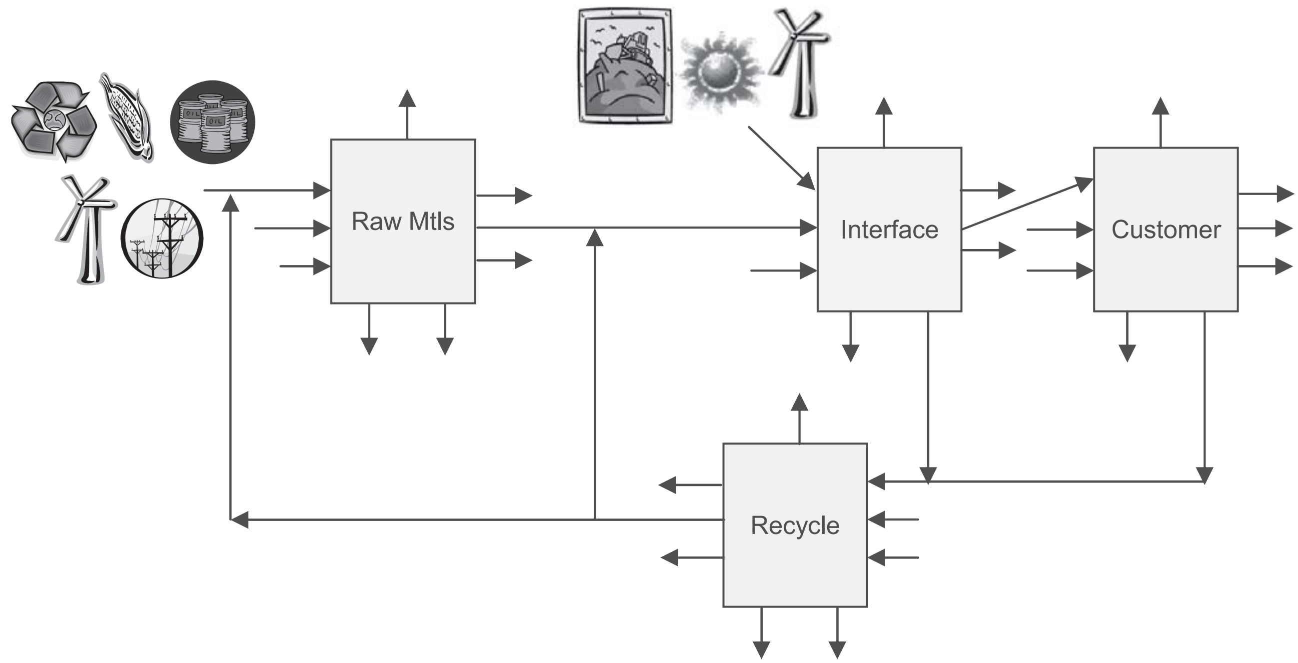

Figure 4. Interface carpet was redesigned to have less mass and to be recycled. That enabled phase-in of a different system (and business model) with the nutrient feedback loop as shown.

This system is not 100 percent efficient, no system is. Virgin inputs are still required to maintain the same production rate. However, it significantly reduced virgin inputs that are used one time; then sent straight through to assimilation. It has also allowed Interface to take financial advantage of our waste streams.

Going Forward

Interface has made significant improvement using sustainable business practices over the past 14 years. Our experience tells us that business can improve for the sake of the environment, society, and financial reasons. They are not mutually exclusive goals or at odds with one another. The more we understood beyond our own old system boundaries the more we were able to improve.

Interface has made tremendous strides in reducing our impact and improving our financial margins. But we still have a lot of work to do. And this issue is much bigger than Interface. We all have to improve together because the environment only understands aggregate industrial activity. Nature doesn't negotiate or compromise. In fact, it's foolish of us to think otherwise.

Financially bankrupt businesses are not sustainable. But morally and environmentally bankrupt businesses aren't sustainable either. We have to consider all three of these issues if we are going to be sustainable entities in the future. The very essence of quality of life depends on it.

Dave Gustashaw is assistant vice president. supply chain and engineering, Interface, Inc. Atlanta, GA. He headed the landfill gas project that won the EPA environmental award in 2005. Robert W. "Doc" Hall is editor-in-chief of Target Magazine.