# Indicators of Sustainable Production – Tracking Progress

A Case Study on Measuring Eco-Sustainability at Guilford of Maine, Inc.[1]

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## Introduction

Over the past ten years, firms, government and the public have increasingly focused on measurement tools to assess the environmental aspects of sustainability. While there are numerous lists of environmental performance indicators (see, for example, International Organizations for Standardization's ISO 14301), these lists provide little insight into how firms might revise their indicators to better measure sustainability. The Lowell Center for Sustainable Production at the University of Massachusetts Lowell has developed a tool to enable companies to evaluate the effectiveness of sustainability indicator systems. The tool (called the Lowell Framework) consists of five levels for categorizing existing indicators relative to the basic principles of sustainability. The purpose of the framework is not to judge indicators as good or poor, but rather to present a lens through which firms can evaluate and improve the sophistication of their measurement efforts. In its current state, the framework focuses on environmental, health and safety aspects of production. Work is underway to expand it to include social and economic aspects.

This case study reviews the environmental performance measurement systems used at Guilford of Maine. It explores how Guilford tracks its progress, the success the firm has seen over the past five years reducing its impacts, and important lessons for others considering implementing similar measurement systems. Lastly, using the Lowell Framework, the case study suggests a new set of indicators to improve Guilford's ability to measure its sustainable production efforts.

## Guilford of Maine

Guilford of Maine is a subsidiary of Interface, Inc. a Fortune 500 flooring manufacturer. Guilford employs roughly 900 persons under ~1.2 million square feet of manufacturing space at four New England plants (2 plants in Guilford, ME, a third in Newport, ME and the fourth in East Douglas, MA). Guilford is a vertical textile manufacturer whose main product is panel fabric for the office furniture market. Other products include fabric for chairs and wall covering.

Guilford's four integrated manufacturing plants take in raw polyester fibers and perform a series of operations including dying, blending, yarn making, weaving, and finishing – to produce a finished fabric product. The company competes on price, quality and delivery and currently has ~60% of the office panel fiber market. Guilford's main product line is Terratex® -- a fabric made from 100% post-consumer or post-industrial waste such as plastic soda bottles, film and

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[1]Prepared by Timothy J. Greiner, Greiner Environmental, for the Lowell Center for Sustainable Production. Work on this project was funded by the Switzer Foundation and the Merck Family Fund. Mr. Greiner would like to thank Paul Paydos and Dave Walker of Guilford of Maine for cooperation in this project.

packaging materials. About 240 pop bottles (made with PET plastic) are recycled to produce 20 yards of Terratex® fabric—enough to create a typical office workstation.

As a subsidiary of Interface (roughly 20% of corporate sales), Guilford of Maine is fully engaged in its parent company's efforts to become a leader in corporate sustainability. Interface's CEO Ray Anderson has challenged his firm to become the first truly restorative enterprise on the planet:

*"In 1994, I offered the task force a vision: to make Interface the first name in industrial ecology worldwide through actions, not words. I gave them a mission: to convert Interface to a restorative enterprise; first by reaching sustainability in our practices, and then becoming truly restorative--a company returning more than we take--by helping others reach sustainability. I suggested a familiar strategy including: reduce, reuse, reclaim, recycle (later we added a very important one, redesign); adopt best business practices and then advance and share them; develop sustainable technologies and invest in them when it makes economic sense; and challenge our suppliers to follow our lead."*

Interface's path towards sustainability, laid out by Ray Anderson in his book *Mid-Course Correction*, follows what Anderson calls the "Seven Fronts of Sustainability":

Figure 1: Seven Fronts of Sustainability

1. *Eliminate Waste* - The first step to sustainability, QUEST (Quality Utilizing Employee Suggestions and Teamwork) is Interface's campaign to eliminate the concept of waste, not just incrementally reduce it.
2. *Benign Emissions* - We're focusing on the elimination of molecular waste emitted with negative or toxic impact into our natural systems.
3. *Renewable Energy* - We're reducing the energy used by our processes while replacing non-renewable sources with sustainable ones.
4. *Closing the Loop* - Our aim is to redesign our processes and products to create cyclical material flows.
5. *Resource Efficient Transportation* - We're exploring methods to reduce the transportation of molecules (products and people) in favor of moving information. This includes plant location, logistics, information technology, video-conferencing, e-mail, and telecommuting.
6. *Sensitivity Hookup* - The goal here is to create a community within and around Interface that understands the functioning of natural systems and our impact on them.
7. *Redesign Commerce* - We're redefining commerce to focus on the delivery of service and value instead of the delivery of material. We're also engaging external organizations to create policies and market incentives that encourage sustainable practices.

Interface's efforts to achieve Ray Anderson's vision are well documented. For example, Interface developed Solenium with a first-of-its-kind option to lease carpet such that Interface can take back the carpet at the end of its useful life and recycle the carpet into new flooring. Solenium uses 30% fewer raw materials to make than conventional carpeting, yet Interface claims it provides superior performance -- by lasting longer, being easier to clean, and eliminating many indoor-air problems. Its production uses roughly a third less energy than conventional carpet. Its manufacturing looms are operated in part by solar energy. Its two principal constituents can quickly and easily be "zipped apart" by applying heat, yielding raw materials that can be reused as feedstock for new Solenium flooring.

Guilford of Maine has been part of Interface's sustainability revolution. Guilford's waste reduction and environmental sustainability efforts range from very practical equipment modifications to reduce water and energy use – to far-reaching research aimed at reformulating products from more sustainable raw materials (See Table 1 below)[2].

Table 1: Environmental Sustainability Efforts at Guilford of Maine

| Efficiency and Productivity Changes | Fundamental Product and Process Changes |
|---|---|
| • When motors and lighting fixtures fail, Guilford requires replacement with high efficiency motors and lights.<br>• At one its plants, Guilford reduced the number of dye chemicals from 35 to eight while simultaneously reducing their aquatic toxicity. The same plant eliminated 700,000kwhrs of electricity use through conservation and retrofit lighting.<br>• At one facility, staff installed variable frequency drives on a boil draft fan motor, as well as the over fire and under fire motors that run on a computer program, reducing annual fuel consumption by 24% and increasing steam output 10%. | • Guilford worked with its suppliers to develop a process that uses recycled PET (mainly soda bottles) to make its Terratex® fabric<br>• Guilford is working with suppliers to evaluate every textile chemical (the firm uses >300 dying, finishing, warping, and other processing chemicals) to reduce their aquatic toxicity.<br>• Guilford is researching methods to dye a corn-derived polymer that one day may be made into Guilford fabric or Interface carpet tiles. The renewable corn polymers would replace the firm's current petrochemical-derived textile fibers. |

In 1999-2000, Guildford provided sustainability training for each of its employees. The training gave every employee – including production workers, maintenance staff, office secretaries, supervisors, purchasing staff, etc., -- basic training on sustainability, Ray Anderson's vision, the Natural Step, etc. The training was well received – to the extent that several employees requested Guilford's trainers teach the course in area public schools.

## EcoMetrics

In 1995, to measure the firm's environmental improvements, Interface established a corporate-wide effort to quantify resource use and waste generation called "EcoMetrics." As an Interface operating unit, Guilford of Maine is responsible for collecting its own resource use and waste generation information and providing that information to Interface's research and development

[2] In 1994, Guilford (and all other Interface subsidiaries) implemented a program called QUEST (Quality Utilizing Employee Suggestions and Teamwork). QUEST was Guilford's first attempt to systematically examine operations for waste reduction opportunities. QUEST was later combined with the company's EcoSense sustainability program to create a single initiative called QUEST/EcoSense.

arm, Interface Research Corporation (IRC). IRC in turn, compiles the various operating unit data into the company's corporate annual report.

EcoMetrics requires Interface operating units to track material flows in three categories: take (raw materials), make (product) and waste (non-product outputs). To get a sense of the scale of the EcoMetrics program, consider that in 1996 Interface took 529,282,000 pounds of raw materials with 13,000,000,000,000 BTUs of embodied energy, combined them with 2,000,000,000,000 BTUs of process energy, and produced 449,490,000 pounds of product, 20,894,000 pounds of solid waste, 577,132,300 gallons of wastewater, and 1,408,000 pounds of regulated air pollutants[3].

Guilford instituted its EcoMetrics tracking system in 1996 – phasing in the data collection effort over a two-year period. During the first year, the company measured its fiber inputs but not its chemicals or recyclables. In its second year (1997), the company improved on the system and tracked all of its material flows. Guilford compiles its EcoMetrics data on a quarterly basis and posts its data annually on its Terratex® web site (www.terratex.com)[4]. Figure 2 below lists Guilford's EcoMetrics data elements.

Figure 2: Guilford EcoMetrics Data Elements

Take
- **Fibers** (including polyester, recycled polyester, polypropylene, nylon, wool, & composites
- **Chemicals** (including dyes, oils, finishes, adhesives, etc.)
- **Auxiliary Materials** (such as cardboard, plastic packaging, office paper, etc.)
- **Energy** (electricity, natural gas, fuel oil & wood)
- **Water**

Make
- **Finished Fabric**

Waste
- **Solid Waste**
- **Recycled Materials** (plastic, cardboard, fabric, metals, plastic, etc.)
- **CO2 emissions**

Like most corporate accounting systems, Guilford's system tracks inventoried items very well. Producing *quarterly EcoMetric reports* for inventoried items such as fiber, yarn, chemicals, etc is simple and requires accounting to generate a set of standard reports. Data from these reports are entered into a spreadsheet and summary reports are prepared.

Non-inventoried items on the other hand are much more difficult to account for since they are expensed (and therefore not inventoried). Since the items are not in inventory, the accounting system cannot generate the standard reports on usage or waste for these items. Example non-inventory items include packaging, cardboard, supplies, and paper. Furthermore, many of these

[3] Interface 1996 Sustainability Report
[4] Terratex® is the brand name for its 100% recycled polyester fabric and is the main product produced by Guilford of Maine.

items are billed by count and not by weight – requiring Guilford staff to convert the data to pounds to include in the EcoMetric reports.

While each of Guilford's four facilities tracks its non-inventory items differently, the system employed by the East Douglas facility is illustrative of the manner in which Guilford tracks its non-inventory items. The East Douglas facility uses individual receipts, purchase orders, and bills and compiles a running summary of materials in a spreadsheet. Items include:

- Oil – measured and recorded monthly
- Electricity – data is entered into a spreadsheet from the monthly bill
- Water – measured daily and recorded
- Solid Waste – data is entered monthly from the vendor's weigh bill for cardboard, paper, plastic, and metal
- Propane – data from purchase slips are entered at the time of purchase
- Waste fabric – is shipped to a Rhode Island vendor that forwards the weight amount to Guilford corporate purchasing

Tabulated data from the East Douglas facility is sent on a quarterly basis to the main Guilford plant were the data is combined with data from other facilities. The table below lists Guilford's 10 EcoMetrics. Note that nearly all metrics are normalized to production (i.e., lbs of solid waste *per linear yard of fabric*). The data demonstrates the remarkable improvements the company has seen over the past five years, with success in the use of recycled fibers, solid waste, energy, water, and $CO_2$ emissions.

Table 2: Guilford of Maine EcoMetrics

| EcoMetric | Unit | 1996 | 1997 | 1998 | 1999 | 2000 | % change '96-'00 |
|---|---|---|---|---|---|---|---|
| 1. Total Fiber Use | Lbs/In. Yd. | 1.09 | 1.02 | 1.07 | .94 | .96 | -12% |
| 2. Non-Recycled Total Use | Percent[5] | 99% | 74% | 48% | 46% | 37 | -63% |
| 3. Recycled Fiber | Percent | 0.8 | 32.5 | 62.6 | 66.1 | 69.8 | 8,625% |
| 4. Chemical Use[6] | Lbs/Lin. Yd. | | 0.11 | 0.10 | .11 | .10 | -9% |
| 5. Auxiliary Materials Use | Lbs/Lin. Yd. | 0.06 | 0.05 | 0.06 | .10 | .09 | 50% |
| 6. Total Materials Use | Lbs/Lin. Yd. | 1.15 | 1.17 | 1.23 | 1.15 | 1.15 | 0% |
| 7. Energy Use | BTU's/Lin. Yd. | 30,101 | 25,621 | 23,745 | 22,418 | 20,717 | -31% |
| 8. Water Use | Gal/Lin. Yd. | 14.16 | 11.94 | 10.82 | 10.89 | 9.37 | -34% |
| 9. Solid Waste Generated | Lbs/Lin. Yd. | 0.078 | 0.068 | 0.052 | 0.041 | .025 | -68% |
| 10. $CO_2$ Emissions | Lbs/Lin. Yd. | 3.53 | 2.97 | 2.7 | 2.56 | 2.37 | -33% |

The Terratex® web site lists the annual data for five of these metrics. The website explains that Guilford has considerable work ahead, since "manufacturing the 20 yards of fabric used in a typical office workstation requires 2.2 pounds of dyes and chemicals, 1.5 pounds of packaging, 248 gallons of water, 500,000 BTUs of energy (3.5 gallons of oil), 50 pounds of carbon dioxide

[5] Post consumer or post industrial recycled raw materials (mainly polyester).
[6] Percent change calculated for '97 – '00.

emissions, and 1.7 pounds of solid waste for landfills. (Graphs from the Terratex® web site are replicated in Exhibit I.)

## *Lessons Learned*

It took Guilford of Maine two years to put the EcoMetrics program into place. Now in its fifth year, the company has streamlined its process of aggregating quarterly data from the various sites into a centralized database. According to Paul Paydos, VP of Technical Services, Guilford of Maine has learned several important lessons along the way.

### Lesson #1: The Denominator Dominates

Finding an appropriate normalization factor for Guilford's EcoMetrics remains difficult. Guilford uses linear feet of fabric produced. However, Guilford makes many different products in addition to its main Terratex® line. In addition, Guilford performs processing steps such as finishing, dying or weaving operations for other Interface subsidiaries. Each of the lines and processes has different process requirements – and correspondingly different environmental impacts in terms of energy, water, raw materials and waste. Since the production of any single line or work for other Interface subsidiaries changes year to year, Guilford's denominator (linear yards of fabric produced) does not track precisely with environmental impact. There is no simple solution to this problem, according to Paul Paydos. While the denominator is not perfect, it does give Guilford an adequate measure of performance over time.

### Lesson #2: The Better You Measure, The Worse You Look

During the first year of the EcoMetrics program (1996), Guilford concentrated on measuring the majority of the firm's inputs and outputs. Each year, as Guilford refined its system, the company found raw materials, auxiliary materials, and wastes that had not been previously accounted for. For example, in '98-'99, Guilford developed a system for better measuring auxiliary materials (cardboard, plastic, paper, packaging, etc.). Guilford did not have the historical data to recalculate prior years. The resulting EcoMetrics data gave the appearance that from '98-'99, Guilford used 60% more cardboard and packaging on a per unit basis. But the improved accounting system yielded benefit by giving Guilford the ability to focus on the auxiliary materials. As a result, the company increased its use of recycled paper and cardboard. (It's worth noting that while the firm's indicators show continuous improved performance, had the base year (1996) data reflected all of the impacts Guilford currently measures, the EcoMetrics would show greater progress.)

### Lesson #3: The Devil is in the Non-Inventoried Items

Non-inventory items – which tend to be waste and utility inputs (e.g. wastewater, propane, electricity, cardboard, scrap textile, etc.) – are the most time consuming items to track in Guilford's system. Not only are they not part of the accounting system, but the items are often not measured in pounds – the unit of measure for many of Guilford's metrics.

Lesson #4:  Metrics Matter When They Hit Home

Guilford's EcoMetrics are part of the firm's profit sharing program and its 401K program.  But while employees know that their bonus and retirement depends in part on Guilford's EcoMetrics, Paul Paydos explains that the employees need to know more precisely how their actions affect the environment.  Furthermore, profit sharing plans typically provide feedback to employees only at the end of the year, rather than on a more frequent (daily or weekly) basis.

Paul Paydos believes that consistently providing the right kinds of data to the right audience is an effective way to motivate employees.  Paydos cites how Dave Walker, a Guilford facilities engineer, charts water and energy consumption and reviews the data in staff meetings.  Focusing on this data led Guilford staff to identify and implement modifications to reduce energy and water use.  (see "Employee Suggestion" Text Box).  According to Walker, the company had been monitoring water use throughout its mills for years.  But it wasn't until he started creating graphs and providing them to employees, dye house mangers, and plant managers, that change began.

**Employee Suggestion**

In the Guilford, ME stock dye house, a step in the process calls for hot water contact with the fibers in order to compress them.  Spin finish put on the fibers by the supplier made the hot water milky and unusable.  A dye house employee suggested working with the vendor to eliminate the spin finish – allowing Guilford to reuse the hot water multiple times rather than wasting the water, spin finish, and its heat value, to drain.

Lesson #5:  Measure, Measure, Measure

Guilford's focus on getting better data for the EcoMetrics program led to reducing material and energy use and cost savings.  For example, the company purchased a recording meter for 3-phase power.  After installing it on a on 45 hp motor in the boiler water pump, the facilities engineer discovered that the motor was running without regard to demand.  By controlling the pump based on the boiler's water need, Guilford reduce pump electricity use 30% and saved approximately $12,000 per year.

Water meters have been similarly effective at revealing cost-saving options at Guilford.  After installing several water meters at one facility, process and facilities engineers got "invaluable information that (we) did not have before to evaluate (several) wasteful processes."  The information was also given to accounting staff so they could better capture certain product-related costs.

## The Future of Eco-Sustainability Measurement at Guilford

The Interface/Guilford EcoMetrics program is designed to quantify resource use and waste generation.  But as Guilford moves beyond eco-efficiency, the EcoMetrics program may need to be modified to measure the firm's sustainability efforts.  How could Guilford's current indicators be modified to better measure Ray Anderson's Seven Fronts of Sustainability?

The Lowell Framework

A useful way to think about expanding Guilford's indicators is through a framework developed by the Lowell Center for Sustainable Production and known as the Lowell Framework[7]. Underlying the Lowell Framework are three basic assumptions. First, developing sustainable systems of production is a continuous, evolutionary process of setting goals and measuring performance. Second, different companies and different industries are starting at different places in the evolutionary process. Third, developing truly sustainable systems of production cannot be achieved by companies or industry alone but rather requires cooperation and coordination among companies, communities and government at many different levels – local, regional, national and international.

The Lowell Framework consists of five levels, each building on the previous level. *Level One Facility Compliance/Conformance Indicators* evaluate the extent to which a facility is in compliance with regulations or in conformance to some industry/association standards. Most companies already track Level 1 indicators, which are focused on activities within facility boundaries and usually developed in response to external regulations or requirements. Examples of Level 1indicators include

- Number of reportable spills
- Number of notices of non-compliance

*Level Two Facility Material Use and Performance Indicators* include measures of facility/company inputs, outputs and performance, such as resource use efficiency, byproducts, emissions, or waste. Examples include:

- Tons of sludge generated
- Tons of air emissions
- Total kWh energy consumed per pound of product output

*Level Three Facility Effects Indicators* measure the potential effects of a facility/company on the environment and public health. Sample indicators include

- Pounds of greenhouse gas (GHG) emissions per year measured in $CO_2$ equivalents (Global Warming Potential - GWP)
- Pounds of photochemical ozone creating emissions per year measured in ethylene equivalents (Photochemical Ozone Creating Potential – POCP)
- Pounds of acidifying substances per year measured as $SO_2$ equivalents (Acidification Potential).

Environmental effect categories include climate change, ozone depletion, acidification, eutrophication, dispersion of toxic substance, solid waste, and disturbance of local environments. Note that up to this point, the indicator levels have been focused primarily on the company's internal production processes. Even at Level 3, indicators are developed to measure effects of the internal production processes on the external environment. Unlike Level 1 and 2, these measures

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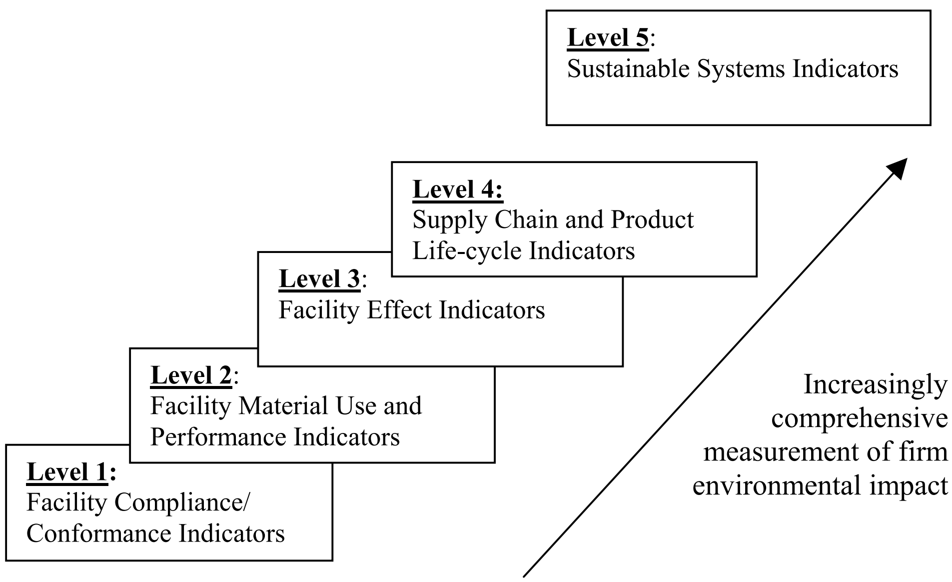
[7] The Lowell Framework is designed to work on integrated (i.e., environmental, social, and economic) indicators. But since case study focuses focuses primarily on eco-sustainability, only the environmental aspects of the framework are discussed herein. The Lowell Center's Principles of Sustainable Production are outlined in Exhibit II.

aim to aggregate the contribution of different sources of these effects. For example, methane and $CO_2$ emissions can be added to calculate global warming potential.

At *Level Four Supply Chain and Product Life-Cycle Indicators*, the measurement focus goes beyond the boundary of the company/facility to look at the supply chain as well as product distribution, use and ultimate disposal. These indicators aim to measure impacts throughout the product life cycle. At this level a company or facility can use indicators found in Levels 1 - 3 but also includes the impacts from suppliers, distributors and end users. Level 4 indicators look at using raw materials from renewable sources and/or reusing or recycling products at the end of their life. Examples of Level 4 indicators include:

- Percentage of products designed to be easily reused or recycled
- Percentage of suppliers receiving safety training per year
- Embodied energy in key raw materials and packaging
- Tons of GHG emissions generated during product transportation.

Figure 3: Lowell Framework




Lastly, *Level Five Sustainable Systems Indicators* show how an individual company's production processes fit into the larger picture of a sustainable society. Sustainable production is not an isolated activity. It is a part of the larger economic, social and environmental systems of a community. In this context community refers to both local community (where a company's facility is located) and global community (where a company sells its products or receives raw materials and parts). Level 5 indicators measure the effects of production on the long-term quality of life and human development within the ecological carrying capacity. They look at the extent to which materials and ecosystem services used by the company (throughout the supply chain and life cycle of the products) have been consumed within the renewable rates or assimilation capacity of nature. In most cases, Level 5 indicators cannot be developed by an individual company but rather need input from community and government in determining limits and thresholds. Examples of Level 5 indicators include:

- Percent of water from local sources used within average local recharge rate
- Percent of total energy used from renewable sources harvested sustainably

It is important to note that the levels are evolutionary. As a company begins to develop indicators at higher levels, the framework does not suggest dropping indicators at the lower levels. It is necessary for companies to comply with regulations and industry standards (Level 1). It will always be important that companies monitor their efficiency and productivity (Level 2). In order to move toward sustainable production, however, an organization needs to look beyond its boundaries at the impacts of suppliers, distributors and products (Levels 3 and 4) as well as effect on ecological systems (Level 5).

It is important to note that the Lowell Framework indicators are numeric in nature and focus primarily on measuring environmental outcomes as opposed to policies and programs (for example, number of persons or suppliers trained on sustainability)[8].

<u>Applying the Lowell Framework</u>

Table 4 categorizes Guilford's current EcoMetrics under the Lowell Framework as well as two other sets of indicators: (a) those indicators that are part of the Interface corporate EcoMetrics program that Guilford does not currently track [*denoted in italics in the table*] and (b) suggested new indicators.

Table 4 shows that many of the metrics currently employed by Guilford fall into the Lowell Framework Level 2 category with a few in Levels 3 and 4. The suggested indicators (which include the italicized metrics that are part of the Interface EcoSense program but for which Guilford does not compile information) fall mainly in Levels 3 and 4 and offer increasingly sophisticated measures of Guilford's sustainability performance. We have suggested only a single Level 1 indicator since Guilford has a strong EMS in place at its plants and manages its compliance responsibilities fastidiously. Guilford however may choose to add additional Level 1 indicators (such as dollar amount of fines, number of sites 14001 certified, or number of reportable spills). Only a single Level 5 indicator is suggested since there is little data to determine how Guilford's impacts fit within the carrying capacity of natural systems such as a water or air shed. Such data may be available for forest products now that programs exist to certify sustainable forestry management practices.

[8] That's not to say that the Framework could not be used to classify various policies, procedures, programs or initiatives into the five level framework. In fact doing so could clarify at what level a firm is targeting its resources. Interface, for example, could apply the framework to its EcoSense program.

Table 4: Current and Suggested Future Indicators

| Framework Level | Eco Metrics Used Currently by Guilford | Suggested Indicators |
|---|---|---|
| *Level 1:*<br>Compliance/ Conformance | None | • Number of violations |
| *Level 2:*<br>Facility Material Use and Performance | • Material Use Efficiency (Fiber, Chemicals & Auxiliaries)<br>• Solid Waste<br>• Water<br>• Energy Use | • *Emissions Inventory -- (From all stacks and vent pipe, estimated type and amount of pollutant in tons or gallons per year)*<br>Convert emissions inventory into environmental impacts |
| *Level 3:*<br>Facility Effects | • CO2 Emissions | • *Transportation Global Warming Emissions*<br>• *Facility Global Warming Emissions*<br>• Environmental Impacts (i.e., Acidification, Photochemical Oxidation Potential, and "Bad Actors[9]", Greenhouse Gases, Particulates, Eutrophication, and Aquatic Toxicity. |
| *Level 4:*<br>Supply Chain and Product | • Percent non-recycled fiber<br>• Mass of product per linear yard (a measure of dematerialization) | • *% Recycled Content for Each Raw Material*<br>• *Raw Material Embodied Energy content*<br>• % Fabric (product) returned to nutrient cycle<br>• % Fabric (product) returned to technical cycle<br>• Supply chain environmental effect (i.e., Acidification, Photochemical Oxidation Potential, and "Bad Actors", Greenhouse Gases, Particulates, Eutrophication, Aquatic Toxicity, and Bad Actors<br>• % Renewable content in products<br>• Service intensity of product per linear foot |
| *Level 5:*<br>Sustainability Indicators | | • % Renewable Energy (for wood, include only energy derived from certified forests) |

Several of the suggested indicators could be readily implemented while others would require more effort. Preparing Level 3 environmental impact indicators requires a comprehensive understanding of the firm's emissions as well as access to various conversion factors (such as those that combine NOx and SOx emissions based on their acidification potential). For example, the aquatic toxicity work Guilford is doing with its chemical dyestuff suppliers could be tied into a Level 3 aquatic toxicity indicator. Supply chain environmental effect indicators are rather complicated to develop since the company must have detailed emissions inventory data for its key raw materials -- information that few suppliers have on hand. The process is simpler if LCA-like inventory data for the various raw materials have been compiled and published by government or other sources and placed in the public domain. Interface itself may have compiled such information on raw materials such as polyester or polypropylene.

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[9] Includes relevant emissions of carcinogens, teratogens, mutagens, endocrine disruptors, persistent bioaccumulative toxins (PBTs), and heavy metals.

More readily implemented indicators include facility global warming emissions[10], % renewable content in products, % of fabric returned to nutrient/technical cycles, and % recycled content for each raw material.

From Interface's perspective, these suggested indicators propose new ways to measure progress along Ray Anderson's "Seven Fronts of Sustainability." Seven of Guilford's 10 EcoMetrics focus on the first front – eliminating waste. Two recycling metrics (pounds recycled per linear foot of fabric and percent of non-recycled fiber) fit the third front (Closing the Loop) and one metric ($CO_2$ emissions) fits the second front (Benign Emissions). Table 5 depicts how the suggested indicators would improve Guilford's understanding of how the business unit is progressing along the seven fronts. In the table, Guilford's current metrics are italicized.

Table 5: Measuring the "Seven Fronts"

| Front | Current Guilford Metrics (*in Italics*) and Suggested Indicators |
|---|---|
| Eliminate Waste | • *Material Use Efficiency (Fiber, Chemicals & Auxiliaries),*<br>• *Solid Waste*<br>• *Water*<br>• *Energy Use* |
| Benign Emissions | • *$CO_2$ Emissions*<br>• Facility and Transportation air emissions by environmental effect (i.e., Acidification, Photochemical Oxidation Potential, and "Bad Actors[11]", and Greenhouse Gases)<br>• Water emissions by environmental effect (i.e., Eutrophication and Aquatic Toxicity) or by type (i.e., COD, BOD, Temperature, and TSS)<br>• Waste emissions by environmental effect (i.e., "Bad Actors")<br>• Supply chain environmental effect (i.e., Acidification, Photochemical Oxidation Potential, and "Bad Actors", Greenhouse Gases, Particulates, Eutrophication, Aquatic Toxicity, and Bad Actors |
| Renewable Energy | • % Renewable Energy (for wood, include energy derived from certified forests) |
| Closing the Loop | • *% Non-recycled fiber*<br>• % Fabric returned to nutrient cycle<br>• % Fabric returned to technical cycle |
| Resource Efficient Transportation | • BTUs per ton-mile (or linear foot)<br>• Environmental Effect per ton-mile (or linear foot) – i.e., Global Warming Potential, Acidification, Particulates, and Photochemical Oxidation Potential. |
| Sensitivity Hookup | • n/a[12] |
| Redesign Commerce | • Service intensity of product per linear foot<br>• *Mass of product per linear foot* |

[10] Including the global warming potential (GWP) of NOx emissions (which have 310 times the GWP of $CO_2$) from fuel burning operations and other greenhouse gases.
[11] Includes relevant emissions of carcinogens, teratogens, mutagens, endocrine disruptors, persistent bioaccumulative toxins (PBTs), and heavy metals.
[12] Sensitivity hookup relates to increasing the understanding in and around Interface facilities of natural systems and Interface's impact on them. Such a definition does not readily lead to quantitative outcome measures of environmental improvement

## Conclusions

Measuring sustainable production is not a simple process. As organizations increase efforts to be sustainable, their measurement systems must change from simpler compliance and regulatory-driven models of performance evaluation. In our work with U.S. firms at the Lowell Center, we have found that most firms employ Level 1 and Level 2 type environmental indicators. Implementing these measures is not straightforward. But as the Guilford experience shows, there are tangible benefits to measuring a firm's environmental performance. Firms that implemented these Level 1 and 2 measurement systems are beginning to develop Level 3 and Level 4 indicators. These new measures are used in vital ways by firms: (i) to raise awareness and understanding; (ii) to inform decision-making; and (iii) to measure progress toward established goals.

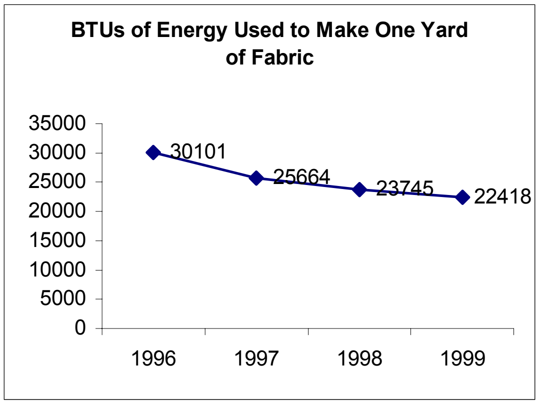
Sustainable production indicators are useful for not only firms, but also for community groups and government agencies. Companies need to "measure" in order to "manage" their achievements. NGOs, community organizations and government need to evaluate companies' performance in order to reward the leaders and determine how best to encourage the laggards to improve their performance.

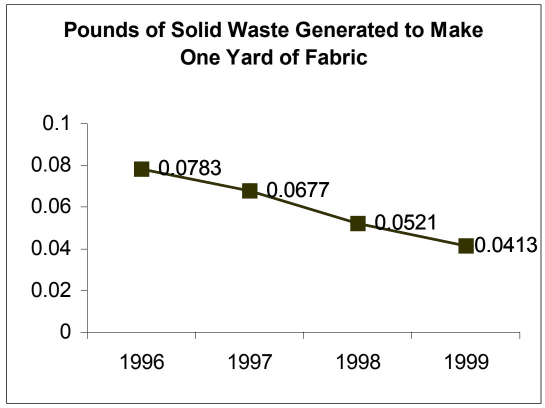
Recently a number of organizations have developed sets of eco-sustainability and eco-efficiency indicators – such as the ones developed under the International Organization for Standardization Environmental Performance Evaluation Guidelines ISO 14031, Global Reporting Initiative, or World Business Council for Sustainable Development – yet these indicator sets do little to help firms understand how environmental performance measurement systems evolve. They provide simple lists of indicators with limited guidance as to how to select or apply them over time in order to become more sustainable [1]. For example, indicators of corporate compliance rates and permit exceedences, while useful, provide little sustainability information. A firm can be in full compliance with government requirements but still making little progress in reducing its impacts on global or local sustainability. Additional indicators are needed to examine, for example, the firm's greenhouse gas emission over time and include estimates of supply chain and product life-cycle contributions. The purpose of the Lowell Framework is to provide firms with an indicator classification system and direction on how the company can better measure its progress towards sustainability.

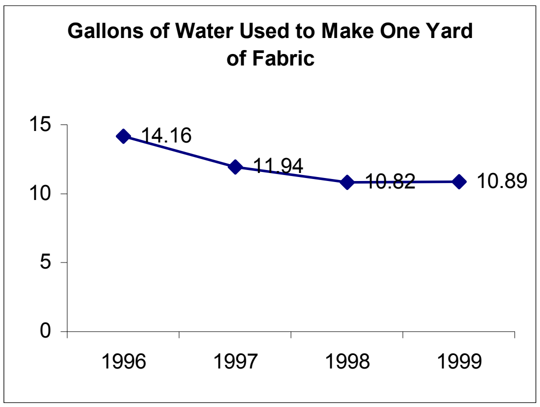
Most industry sustainability indicators put emphasis on one portion of the sustainable development equation (environment) over the other two (social and economic). The social and economic arenas include economic viability, social justice, and community and worker development. While not covered in this case study, the Lowell Center has extended its Five-Level Framework to cover these two areas as well. A full body of indicators, representing the three legged sustainability tool, is vital to show the extent to which an organization is moving toward more sustainable production practices.

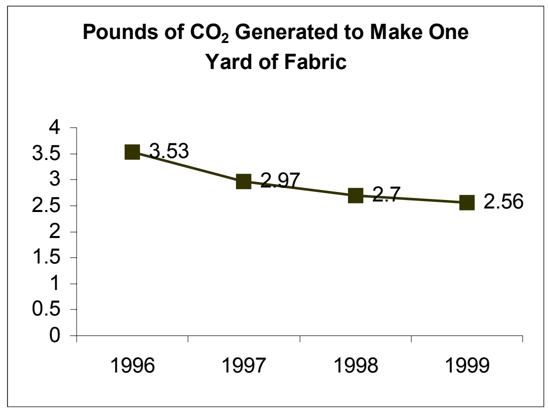
[1] Veleva, V., *A Proposal for Measuring Business Sustainability: Addressing Shortcomings in Existing Indicator Frameworks*, Greening of Industry Network Conference, Chapel Hill, North Carolina, November 13-16, 1999.

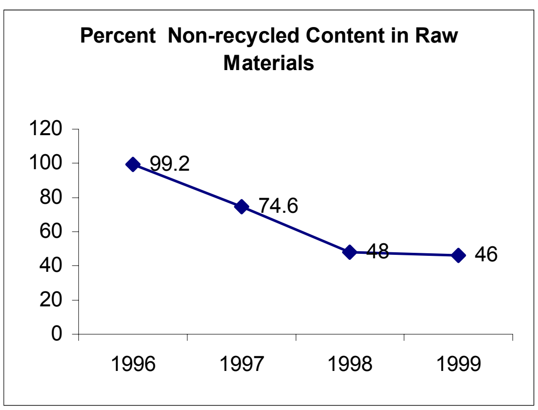
# Exhibit I: Terratex® EcoMetrics



## Exhibit II:  Lowell Center Principles of Sustainable Production

1. Products and services are designed and created to be:
    a) safe and ecologically sound throughout their life cycle;
    b) produced, packaged, and delivered with an optimal amount of material and energy; and
    c) durable, repairable, readily recyclable, compostable, or easily biodegradable, as appropriate.
2. Processes are designed and operated such that:
    a) energy and materials are used within sustainable limits with a preference for renewable forms;
    b) chemical substances, physical agents, technologies and conditions that present hazards to human health or the environment are reduced or eliminated;
    c) work spaces are designed to minimize or eliminate chemical, biological, ergonomic, and physical hazards; and
    d) ecologically incompatible wastes and byproducts are reduced or eliminated.
3. Workers are valued and
    a) they are encouraged and helped to develop their talents and capacities;
    b) their work is organized to enhance their efficiency and creativity and to encourage participation in decision-making; and
    c) their security and well-being are priorities.

4) Communities related to any stage of the product lifecycle (from production of raw materials, though product manufacture, use, and disposal) are respected and enhanced economically, socially, culturally, and physically.

5) Economic performance is enhanced through:
    a) satisfying customers with quality products and services that meet social needs
    b) encouraging stakeholder involvement in decision-making
    c) promoting innovation,

    all while employing increasingly sustainable forms of production.