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How “Sustainability” Is Changing How We Make and Choose Products

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ABSTRACT

What does Sustainability mean, and why should people in the thermophysical properties business care? This paper will describe sustainability in the context of product development, which is where much of the buzz is currently being generated. Once described, it will discuss how expectations for Sustainability are changing product lines, and then discuss the controversial issues now emerging from trying to measure Sustainability.

1. INTRODUCTION

One of the most organized efforts in the U.S. is the U.S. Green Building Council revolutionizing how the built environment is conceptualized, designed, built, used, and disposed of - and born again. The appeal of the U.S. Green Building Council is that it has managed to checklist how to "do" Sustainability. By following this checklist, better described as a rating system, a more Sustainable product should be achieved. That is, a product that uses less energy, less water, is less noxious to the user, and consumes fewer resources. We care because these Sustainable products are viewed as preferable by a growing number of consumers and, consequently, are more valuable.

One of the most interesting aspects of the Sustainability movement is a quantitative assessment of how sustainable a product is. Life Cycle Assessment techniques (not to be confused with life cycle economic costs) developed since the early 1990s are gaining ground as a less biased method to measure the ultimate "bad" consequences of creating a product (depletion of natural resources, nutrification, acid rain, air borne particulates, solid waste, etc.). For example, one assertion is that these studies have shown that recycling can sometimes do more environmental harm than good.

2. SUSTAINABILITY APPLIED TO PRODUCT DEVELOPMENT

William McDonough, one of the pioneers of sustainable design, suggests that we've returned to a hunter-gatherer society. But instead of hunting food, we hunt oil, natural gas, minerals, cellulose, and polymers. We take what we find and move on to find more. We're not sure just where or how much of those resources actually exist, but from past experience we assume that we can find more. Consider that for over two million years, the human population on Earth has been less than one billion. The population reached one billion less than 200 years ago, and may top ten billion this century. Is hunter-gatherer a realistic or sustainable approach to harvesting resources?

The concept of Sustainability is that you behave and use resources in a way that allows future generations to enjoy an equivalent or better quality of life.

People can see that there is a cost associated with our hunter-gatherer approach to resources and our obsession with material accumulation. The cost they literally see is the loss of resources like public land, scarcity of raw materials, and visible pollution. Notice any open space become a subdivision? Has anyone heard a carpenter complain about the quality of lumber? How about gas prices rising? Is the brown haze growing over your town or city?

Again, the idea of sustainability is to use resources in a way that allows at least an equivalent quality of life in the future. This doesn't mean we necessarily have to give up our lavish ways. It means we need to be more clever and re-invent how we harvest, replenish, use, dispose, and harvest again.

More and more articles are appearing in the popular press indicating growing public interest in sustainability. Sustainability means different things to different people. Organic farming appeals to some consumers, but the concept is a little disappointing to the chemical engineers who have developed products that have increased crop yields and greatly reduced world starvation. Biodegradable sounds like a good thing, but there are those who argue that it's better to have non-biodegradable products in landfills than to have waste decomposing and creating greenhouse gas (methane). More about these issues later.

Regardless of personal beliefs about what is sustainable or not, businesses are responding to what they hear from the public. One way the public is making their concerns heard is with consumer choice. In the last five years there has been an expansion in the U.S. in the production of products claiming to be natural, green, non-toxic, recyclable, or containing recycled content targeted to appeal to this trend.

3. AN EXAMPLE OF IMPACT ON AN INDUSTRY: GREEN BUILDING CONSTRUCTION

One of the most visible examples of how sustainability is changing product development is what is happening in the building industry. "Green" buildings are structures that optimize design and siting to reduce energy consumption, water consumption, waste streams, non-readily replaceable resources, and the use of toxic materials.

The U.S. Green Building Council is a nonprofit membership organization to promote the design and construction of more environmentally sensitive buildings. Formation began with conversations between founders David Gottfried, a construction manager and developer, and Michael Italiano, an environmental lawyer, in the mid 1980s. The U.S.

Green Building Council incorporated as an organization with less than 30 members in 1993.

The U.S. Green Building Council was originally supported with private and government grants and now sells individual and corporate memberships. The U.S. Green Building Council membership is currently around 8,500 businesses and organizations. The annual conference, Greenbuild, will handle 10,000-17,000 attendees with 600 exhibitors in 2006, up from a few hundred attendees eight years ago.

Turner Construction Company announced the results of a survey of 719 builders, owners, architects, developers, and engineers on green building projects in September 2004. More than half the respondents expected to have a substantial increase in their green building business. Thirty percent stated it was extremely likely that their organization would work on a green building before 2008.

The U.S. Green Building Council owes much of its success to its primary product; a consensus based rating system for buildings, Leadership in Environmental and Energy Design (LEED). LEED was created to:

- define "green building" by establishing a common standard of measurement
- promote integrated, whole-building design practices
- recognize environmental leadership in the building industry
- stimulate green competition
- raise consumer awareness of green building benefits
- transform the building market.

LEED is a rating system designed to provide a measure for how well a building design applies more environmentally benign products and features. LEED currently has four rating editions: LEED for New Construction, LEED for Existing Buildings, LEED for Commercial Interiors, and LEED Core and Shell. LEED for Homes and LEED for Neighborhoods are in draft form.

LEED for New Construction was the first rating edition and is the most evolved form of LEED. Version 2.2 offers 69 available points that can be earned during design and construction of a new building. It consists of checklists of design and construction management elements which, if achieved in the building process, earn “points.” Depending on the points achieved, a building can be Certified (26 points), Silver (33 points), Gold (39 points), or Platinum (52 points).

Points can be achieved in various categories. The five categories in LEED for New Construction are Sustainable Siting, Water, Energy, Materials, and Indoor Environment. An additional category is allowed for Innovation credits, earned by application of a technology or process that is not covered in the other five areas.

The table below describes the nature of the elements addressed in each of the five areas.

Table I. Summary of LEED for New Construction Points, Version 2.2.

Category/possible points	Summary
Sustainable sites 14	Requires an erosion and sediment control plan. Site must not be on prime farmland, on land lower than 5 ft. above a 100 year flood plain, on a protected habitat, within 100 feet of wetlands, within 50 feet of a water body, or on public parkland. Offers points for: • constructing on a previously developed site or within ½ mile of residential and basic services • brownfield redevelopment • locating near mass transit • bicycle storage and showers for 5% of occupants • preferred parking for alternate fuel and hybrid vehicles • limiting parking to ordinance minimum • limiting site disturbance during construction • reducing the development footprint • preservation of open space • implementing a stormwater management plan and system • reducing light pollution • reducing urban heat island effects.
Water efficiency 5	Offers points for: • Reducing water consumption for landscaping by 50% • Using no potable water for irrigation • Reducing waste water, using less potable water, and increasing aquifer recharge • Maximizing water efficiency.
Energy and atmosphere 17	Must use best practice commissioning procedures. Must design to comply with ASHRAE/IESNA 90.1-2004. Zero use of CFC-based refrigerants in HVAC systems. Points offered for: • reducing design energy costs vs. ASHRAE/IESNA 90.1 by 10.5% - 42% • supplying 2.5% - 12.5% of total energy use via on-site renewable systems • using an independent commissioning authority and measures above and beyond basic commissioning • using refrigerants that minimize emission of compounds that contribute to ozone depletion and green house gasses • implementing an energy Measurement and Verification Plan • purchasing utility provided renewable power.
Materials and resources 13	Must provide collection, storage, and delivery of recyclable materials. Offers points for: • maintaining at least 75% - 95% of the existing walls, floors,

	and roof of a building replacement • maintaining at least 50% of interior non structural elements of a building replacement • diverting 50% - 75% of construction, demolition, and land-clearing waste from land fill • using 5% - 10% of total value of materials from salvaged or reused materials and products • using 10% - 20% of total value of materials with recycled content • using 10% - 20% of building materials that are manufactured within 500 miles • using products made from plants that are harvested within a 10 year cycle for 2.5% of the value of all building materials • using 50% of wood-based materials from Forest Stewardship council certified forests.
Indoor environmental quality 15	Must meet minimum requirements of ASHRAE 62.1-2004. Must prohibit smoking in the building or provide verified ventilated smoking rooms verified by tracer. Points offered for: • installing a permanent CO_2 monitoring system and instrumenting mechanical air flow systems • designing ventilation systems that result in air-change effectiveness of 30% more than minimum required • developing an Indoor Air Quality management plan for construction and pre-occupancy phases • flushing and air testing before occupancy • using adhesives and sealants with limited VOC content • using paints and coatings with limited VOC/chemical components • using carpet systems that meet or exceed Carpet &Rug Institute's Green Label Plus program • using wood and agrifiber products containing no added urea-formaldehyde resins • designing to minimize pollutant cross-contamination of occupied areas • providing individual lighting controls for 90% of the occupants • providing controls and monitoring for thermal comfort over time • achieving daylighting and views.

To date there is more than six million square feet of building space that is certified LEED, all designed and constructed since LEED was launched in the year 2000. Three hundred million more square feet are expected in the near future. A high profile building certified LEED Gold early in 2006 is #7 World Trade Center built on the site of the destroyed World Trade Center in New York City. The high-rise tower will generate wind and solar electrical power and use natural daylighting and ventilation strategies.

LEED is not a self-certifying process. To become certified, a building must be built and ready for occupancy. Records and photos kept throughout the design and construction process form the basis for a report that is submitted to the U.S. Green Building Council. The U.S. Green Building Council reviews the paperwork provided for each point the applicant believes has been earned. During the U.S. Green Building Council review, there is usually at least one round of requests for clarification back to the applicant, and the applicant does have at least one chance to appeal rejected points. The final determination of how many points were earned, and, consequently, the level of certification, is made by the U.S. Green Building Council.

Understanding what LEED is and the rigorous level of the certification process enables appreciation for emerging new products. Manufacturers are responding to the demand for building products that will help win certification points.

The LEED rating system has renewed enthusiasm for water and energy efficiency products. In addition, it is sparking development of new building products that have recycled content, are made from renewable bio-based materials, and avoid off-gassing of toxic substances.

Points can be earned using materials with recycled content. Recycled content materials are defined in the International Organization of Standards document ISO 14021 – Environmental labels and declarations – Self-declared environmental claims (Type II environmental labeling). The portion of recycled content in the product is determined by weight. A LEED credit is possible if the sum of post-consumer recycled content plus one-half of the post-industrial content constitutes at least 10% of the total value of the materials in the building project. Post-consumer material is disposed for recycle collection by the consumer, and post-industrial material is from waste streams of the original manufacturing process.

Rapidly renewable materials (generally grown and harvested in a ten-year cycle or less) include linoleum, wheatboard, bamboo, wool, cotton, cork, agricultural fibers, etc. If 2.5% of the cost of the building materials meet the rapidly renewable criteria, a point can be earned.

LEED awards points for limiting indoor air contaminants, mostly Volatile Organic Components (VOCs), emitted by building products. Criteria are suggested for four categories of products: Adhesives & Sealants, Paints & Coatings, Carpet Systems, and Composite Wood and Laminate Adhesives. Composite wood products and laminates used on site can have no added urea-formaldehyde. Paints must meet Green Seal Standards GS-11 and GS-03 for topcoats and anti-corrosive/rust coatings. Other coatings, primers, adhesives, and sealants are limited to VOC levels listed by South Coast Air Quality

Management District Rule 113, Architectural Coatings. Carpeting and cushion must meet the Carpet and Rug Institute Green Label program, including a VOC limit for carpet adhesives.

Product manufacturers are on top of these requirements and are providing products. In the April 2006 issue of *Environmental Design + Construction*, for example, there are advertisements for:

- PVC-free, no VOC fabrics
- rubber flooring
- Forest Stewardship Council-certified lumber
- low-emitting doors
- zero VOC and low odor paint
- textiles made from 100% recycled polyester
- rubber base boards
- recycled masonry blocks
- formaldehyde-free and post-industrial recycled content flooring
- cork flooring
- soy polymer roofing
- roof shakes made of 100% recycled materials
- soy-based insulation.

Would these products be on the market without the influence of the consumer as a result of efforts by the U.S. Green Building Council and similar organizations?

Notice that the LEED standards are generally prescriptive. Room is left for innovation, but the prescriptive requirements of recycled content and VOC limits, among other point topics, are generating interesting discussions. While LEED has succeeded in reaching the goals it was created to accomplish, can a better result be obtained by replacing the prescriptive standards with performance standards? Version 3.0 of LEED-NC will include Life Cycle Assessment techniques, which is sure to result in another level of innovation in sustainability.

4. MAKING THINGS INTERESTING WITH LIFE CYCLE ASSESSMENT

Shaw is a leader in sustainable carpet design. Shaw manufactures EcoWorxs backing and Eco Solution Q Fiber. After the carpet is sold to a customer and becomes worn, Shaw removes the carpet and ships it back to the factory at no cost to the customer. The backing and yarn face are separated, broken down, and reprocessed. The backing returns directly to the extrusion process to become more backing of equal quality and value. The yarn is processed into carpet fiber. Shaw has created a closed loop process: not just cradle-to-grave, but cradle-to-cradle.

The Shaw approach goes beyond what its customers need for LEED points. Not only does the carpet have almost 100% post-consumer recycled content, or could potentially be counted as salvaged material, but it eliminates a solid waste stream, since worn carpet is not disposed of in landfills. This added benefit of the cradle-to-cradle approach would make the Shaw product clearly preferable if carpets were compared to each other more holistically, rather than by a single measure like recycled content.

Actually, are we sure that using products with recycled content accomplishes the intended purpose? Is recycling better for the environment than containing solid waste in a landfill? Consider that the recycling process might require long distance transport by fossil fuel to get the used product to the plant. Then energy, water, and possibly toxic substances will be used for the recycling process. Are the pollutants produced in that process greater than the manufacture of the original product resulting in more harm than if the product was disposed of in a lined landfill?

How should durability be factored in? Is a product made from bio-based materials that only lasts half as long as the same product made from petroleum by-products better? These sticky questions are fueling a new field of study: Life Cycle Assessment.

Life Cycle Assessment is used to evaluate either a product or an activity for environmental impacts (as opposed to cost) by life cycle---cradle-to-grave--- and cradle again. This covers all processes such as extraction and processing of raw materials, manufacture, transport, distribution, use, reuse, maintenance, recycling, and final disposal. As stressed by the European Environment Agency, Life Cycle Assessment is not used to show that a product is environmentally friendly (no such thing); but it can be used to compare the environmental impacts of similar products, provided the criteria are specified and it is recognized that one product might be better than another only in certain aspects of its performance. For example, would an aluminum or a PVC window frame be more environmentally desirable? Aluminum production emits acidifying sulfur and nitrogen oxides, but the production of PVC results in toxic dichloroethane emissions. Life Cycle Assessment is used to quantify the physical amount of the waste stream or emission, and also the degree of toxicity or environmental harm.

Europe has been more involved in developing methodology for Life Cycle Assessment than the United States, although the Society for Environmental Toxicology and Chemistry (SETAC), founded in the U.S. in the 1970s, is recognized by the European community for establishing a generally accepted methodology for performing Life Cycle Assessment, in the "Code of Practice for Life Cycle Assessment." A version of this methodology is found in International Standards Organization 14040 standards.

Life Cycle Assessment can easily involve several hundred processes: extraction of steel, production of copper, transport of chlorine, manufacture of packaging materials, shipping, use, maintenance, cleaning for reuse, transportation for reuse, melting and processing for recycling, reuse, and eventual disposition. Consumption of energy, raw materials, water, and the resulting emissions and waste streams must all be calculated and expressed per unit of function delivered by the product. Then sense must be made of the units of resource depletion or emissions by determining the resulting impact (human health, loss of public land, acid rain, etc.) and the relative value of each stressor based on the desired impact.

Life Cycle Assessment will be described as three steps: Inventory Analysis, Impact Assessment, and Interpretation.

4.1 Life Cycle Assessment Inventory Analysis

Inventory Analysis and Impact Assessment are the labor intensive steps of Life Cycle Assessment processes. Inventory Analysis begins with a process flow chart showing the extraction of raw materials and energy from the environment. This proceeds through multiple stages of production (including transportation loads) and consumption or disposal. Life Cycle Assessment recognizes that products will re-enter the environment as emissions to water, air, and/or the land.

The next step is collecting the data. This has historically been recognized as the most time-consuming and frustrating step of Life Cycle Assessment. Data might be found in scientific literature, such as published data files used by Life Cycle Assessment practitioners, government records, or from industry. More recently there are national and international projects which develop and make available databases on specific sectors or regions, for use by Life Cycle Assessment practitioners.

Defining system boundaries occurs after the data collection step in order to make the analysis manageable. The data must be collected in order to determine the critical processes of the product life cycle. Accepted methodology is to focus on the critical elements that have the bulk of the impact on the environment rather than account for every detail that will lose meaning due to error of data measurement tolerances.

The last step of the Inventory Analysis is to process the data. Here the inputs and outputs must be re-expressed with scaling factors into functional units, usually by weight or mass. For example, the table below provided by the European Environment Agency shows the gross inputs and outputs associated with the production of 1 kg of Polyvinyl Chloride averaged over all polymerization processes.

Table II. Inventory for 1 kg of Polyvinyl Chloride.

		Unit	Average
Fuels	Coal	MJ	6.96
	Oil	MJ	6.04
	Gas	MJ	15.41
	Hydro	MJ	0.84
	Nuclear	MJ	7.87
	Other	MJ	0.13
Feedstock	Oil	MJ	16.85

	Gas	MJ	12.71
Raw Materials	Iron Ore	mg	400
	Limestone	mg	1600
	Water	mg	19000000
	Bauxite	mg	220
	Sodium Chloride	mg	690000
	Sand	mg	1200
Air Emissions	Dust	mg	3900
	Carbon Monoxide	mg	2700
	Carbon dioxide	mg	1944000
	Sulfur oxides	mg	13000
	Nitrogen oxides	mg	16000
	Chlorine	mg	2
	Hydrogen chloride	mg	230
	Hydrocarbons	mg	20000
	Metals	mg	3
	Chlorinated organics	mg	720
Water Emissions	COD	mg	110
	BOD	mg	80
	Acid as H	mg	110
	Metals	mg	200
	Chloride ions	mg	40000
	Dissolved organics	mg	1000
	Suspended solids	mg	2400
	Oil	mg	50
	Dissolved solids	mg	500
	Other nitrogen	mg	3
	Chlorinated organics	mg	10
	Sulfate ions	mg	4300
	Sodium ions	mg	2300
Solid waste	Industrial waste	mg	1800
	Mineral waste	mg	66000
	Stags and ash	mg	47000
	Inert chemicals	mg	14000
	Regulated chemicals	mg	1200

4.2 Life Cycle Assessment Impact Assessment

Impact Assessment interprets the inventory analysis in terms of the impact on the environment and human health. This starts with a process of classification.

Classification consists of dividing the impacts by the type of environmental stressor. A stressor can be a result of pollution, resource depletion (land, water, minerals), or other events that potentially reduce the quality of the natural world or human health. Various stressors have been adopted by various approaches. For example, the following table provided by the European Environment Agency compares the designated stressors of three similar Life Cycle Assessment methodologies---SETAC, Nordic, and ISO---and indicates global or local applicability.

Table III. Designated Stressors by Different Life Cycle Assessment Methodologies.

SETAC	Nordic	ISO	Scale of Impact
Abiotic resources	Energy and materials	Abiotic resources	Global
Biotic resources		Biotic resources	Global
	Water		
Land	Land	Land use	Local
Global warming	Global warming	Global warming/ climate change	Global
Depletion of stratospheric ozone	Depletion of stratospheric ozone	Stratospheric ozone depletion	Global
Human toxicological impact	Human health, toxicological excluding work environment	Human toxicity	Global, continental regional, local
	Human health, non-toxicological excluding work environment		
	Human health impacts in the work environment		Local
Ecotoxicological impacts	Ecotoxicological impacts	Ecotoxicity	Global, continental, regional, local
Photo-oxidant formation	Photo-oxidant formation	Photochemical oxidant formation (smog)	Continental, regional, local
Acidification	Acidification	Acidification	Continental, regional, local
Eutrophication (including BOD and heat)	Eutrophication	Eutrophication	Continental, regional, local
Odor			Local
Noise			Local
Radiation			Local, regional
Casualties			Local
	Habitat alterations and impacts on biological diversity		Local

The second step of Impact Assessment is characterization. In the characterization phase, the data are expressed according to their contribution to the stressors. This is a quantitative process where like contributors are expressed in comparable units. For example, a methane emission contributes to global warming and is expressed in terms of equivalent tons of CO_2.

4.3 Interpretation

The last step is valuation and interpretation. Valuation is subjective, depending on the goal of the Life Cycle Assessment, and the stressors of concern. SETAC does not present rules for valuation; it could be left to a panel of experts or the desire of the customer.

Because the variables are multiple, and the issues are complex, it's often tempting to address a single stressor. For example, the carbon cycle is a politically visible issue at present. Carbon trading is under consideration as a policy for incentivizing upstream carbon removal, carbon capture, sequestration, energy efficiency, alternate energy, etc. Life Cycle Assessment can be used to measure embedded equivalent tons of CO_2 emitted or avoided per alternative. But if financial incentives are developed, they should be based on whole life cycle information based on multiple stressors, not merely by tons of carbon avoided or sequestered.

The National Institute of Standards and Technology convened a workshop in May 2006 to bring together subject matter experts to discuss weighting of stressors. The outcome of this event might lead to more standardization of the weighting process and most likely will identify many research needs and questions.

Once weights for the importance of the stressors are agreed upon, whether by the requestor of the Life Cycle Assessment, a team of experts, or a national weighting standard, a single environmental score for the product or process under analysis could potentially be calculated for comparison with similar products or processes. Any time a single environmental rating or score is stated, it should be taken with insight into the subjectivity of the valuation and interpretation step.

An example of Life Cycle Assessment use is the highly publicized study of vinyl products. Other green building rating systems outside the U.S. offer incentives for the avoidance of vinyl building products based on the carcinogenic nature of byproducts from manufacture and some disposal methods for vinyl. The U.S. Green Building Council was under pressure from members to provide LEED points for avoiding vinyl at the protest of the vinyl industry. A Life Cycle Assessment study was commissioned: the findings reported that PVC "does not emerge as a clear winner or loser." Apparently, the energy efficiency and resource conservation benefits of PVC were viewed as a counter-weight to human health risk of the toxic byproducts. Since the valuation remains a subjective step, the report was subsequently criticized as not having the right weightings on the stressors.

A powerful use of the Life Cycle Assessment analysis is to identify which steps and processes in the manufacture of a product contribute excessively to environmental concerns. This is a tool for product designers and manufacturers to creatively find alternative raw materials or processes that will make Life Cycle Assessment results more favorable. The vinyl industry would be well-served to review the processes that contribute unfavorably and find creative solutions.

5. THE FUTURE

Will the future bring product rating systems based on global, standardized criteria? Will what you know about the embedded energy, resource depletion, toxins, and waste streams make a difference in what you buy and how you use it? Will your next cup of coffee be in a ceramic cup or a paper cup? Do we need this kind of stress in our lives?

Fig. 1. Will labels expressing embodied environmental contributions be the future of sustainable consumption?

The perceived environmental consequence of products is making a difference now to investors in the building industry. Green buildings and products are viewed as progressive and leading edge. It's only a matter of time before other industries adopt a similar approach. Any product manufacturer could get ahead of the curve by commissioning Life Cycle Assessment studies for their processes.

While Life Cycle Assessment is a relatively new field of study with its introduction and evolution occurring in the last three decades, professional services, online tools, and databases exist and are emerging. Examples of emerging tools to assist the Life Cycle Assessment process include the U.S. LCI Database Project (NREL/Sylvatica/Athena Institute), and TRACI, developed by researchers under the management of Jane Bare of EPA.

The U.S. LCI Database Project (funded by DOE, among other sponsors) is developing publicly available data modules for commonly used materials, products, and processes. This database is in response to a growing trend of taking a system's view when evaluating the environmental performance of products and services. The goal of the project is to provide reliable information for the assessment of system environmental performance, particularly when database users need to choose a subsystem or material that carries higher environmental burdens over alternatives.

The U.S. EPA has developed TRACI, the Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (capitalization standardized to EPA model). TRACI is PC software that can be used in Life Cycle Assessment to set corporate environmental goals, plan a path to meet those goals, and then measure environmental progress. TRACI allows for characterization of the following stressors: ozone depletion, global warming, acidification, eutrophication, photochemical smog, human health - cancer, human health - noncancer, ecotoxicity, fossil fuel use, land use, and water use. Both of these tools, the U.S. LCI Database Project and TRACI, are worth looking into but are only a subset of the information and help available.

6. SUMMARY

Whether you study thermophysical properties, help create new products, or buy and use products, it is human nature to want to do the right thing. Just as littering has become unacceptable, environmental protection has become a value in U.S. culture. The demand for hybrid cars is driven by the desire to reduce pollution in addition to saving money with better gas mileage. Consider how much voluntary recycling occurs, and the pride communities have in instituting recycling programs.

Interest in sustainability is an indication that the U.S. consumer is ready to acknowledge the down side to the highest standard of living the human race has ever experienced. Consumers are ready for change in how we make, use, dispose, and remake what is consumed.

A culture of sustainability will result in innovation and new ideas that will drive change in unforeseeable directions. Imagine a world where all inhabitants can achieve the development level of the U.S., without destroying the planet in the process.

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