GRADIENT
TRENDS
Risk Science & Application

Winter 2008

Sustainability: An Overview

By Barbara D. Beck, Ph.D., DABT

Implementing sustainable practices can involve a number of analyses that have not previously been considered.

The concept of sustainable development links environmental protection and economic development. Many refer to the term "sustainable development" using the description in the 1987 Brundtland Report: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Many complexities and questions underlie this seemingly straightforward concept. What does sustainability really mean, practically speaking? What human activities does it encompass? Who is involved? How do we measure sustainability?

…the next challenge will be to understand whether these various indicators together measure progress towards a more sustainable economy and environment.

Of particular importance are the overarching goals of a sustainable development program, how the goals reflect sustainability, and the indicators to measure progress towards sustainability. As discussed by Joy Hecht (http://www.epa.gov/sustainability/pdfs/hecht-epa-ord-paper.pdf), the goal of economic sustainability is simple: "…[T]he ability to generate income is maintained." The goal of ecological sustainability is more complex. Is a sustainable ecosystem one in which species coexist and evolve, but gradually? Or is the goal more anthropocentric, seeking an ecosystem that provides us humans with clean air, food, water, and housing, while we adapt our cultural practices and consumption to maintain the ecosystem?

Sustainability represents a holistic worldview, and developing approaches to achieve sustainability goals necessitates the use of categories. While there are many ways to characterize the concept, the U.S. EPA evaluates sustainability in four broad

continued on pg. 2

I N S I D E

Letter to our Readers

January 2008

Dear Colleague,

In this issue of *Trends,* we broaden our view of the environment to consider sustainability, carbon trading, and alternatives to fossil fuel, all issues that are currently on the political landscape and likely to stay with us for some time to come. We find it interesting that varied organizations look at sustainability in different ways, but all focus on approaching the future in a more environmentally conscious manner.

Contributors to this issue include Dr. Barbara Beck, Gradient Principal and toxicologist, Mr. Neal Grasso, a Gradient environmental engineer, and Ms. Elizabeth Allen, *Trends* Editor and sustainability aficionada. Joining them from DuPont's Corporate Remediation Group is Dr. David Ellis, Manager of Technology Development, who shares his thoughts on sustainability as an additional criterion in remedy selection.

We hope this issue of *Trends* will provide you with fresh insight as you ponder your own carbon footprint.

Yours truly,

Neil Shifrin, Ph.D.
President and Founder

Trends is a free publication of Gradient Corporation, a national leader in risk assessment and negotiation of risk-based remediation. If you have a colleague who would benefit from this publication, please contact Elizabeth Allen at (617) 395-5000 or email us at *trends@gradientcorp.com.*

Gradient
CORPORATION

Sustainability: An Overview

continued from pg. 1

areas: a) the built environment (homes, offices, commercial spaces, *etc.*); b) energy and the environment, including fossil fuel usage, climate change, and security; c) materials and toxics, including not only the release of potentially hazardous chemicals, but also the environmental impact of production and disposal; and d) water, ecosystems, and agriculture, which includes recreational activities, water management practices, and farming practices. Boundaries between these categories are fuzzy. For example, release of methane, a greenhouse gas, from agricultural sources (category d) must be considered in analyzing climate change (category b). A number of companies consider sustainable development in their efforts to build markets in the areas of agriculture and food, building and construction, communications, and transportation. Some, but not all, of these market areas are encompassed in the sustainability categories defined by the EPA.

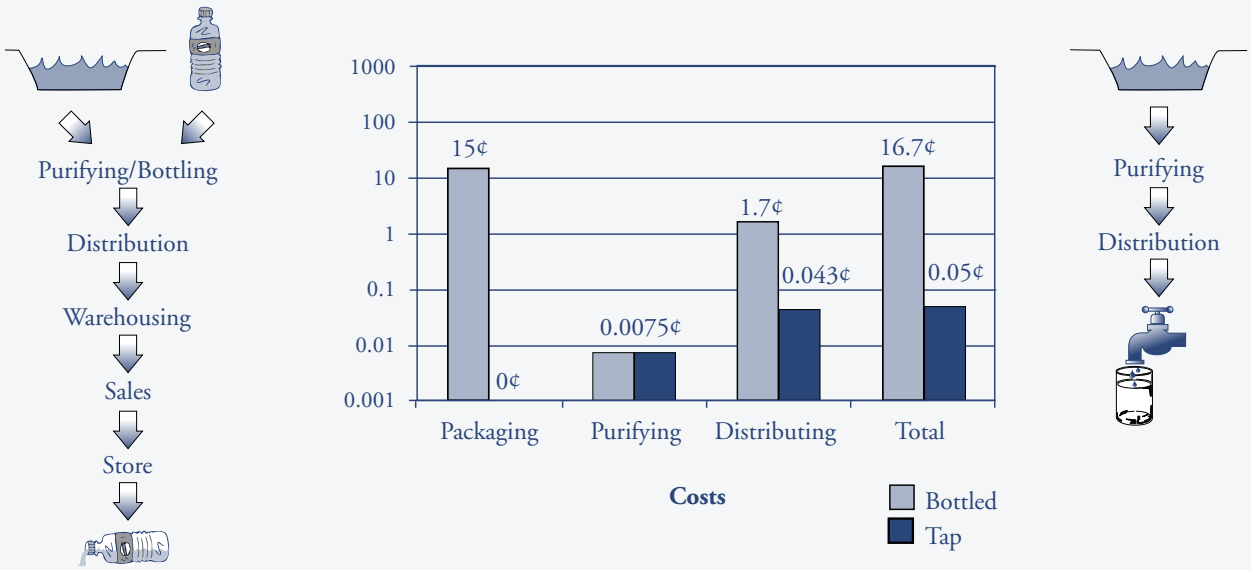
Measures to evaluate the progress towards achieving sustainable development are key. The EPA's assessment and performance measures encompass 12 categories, some focused on specific agency activities (*e.g.,* goals to "green" agency operations, as through the use of green buildings), others on measures of environmental emissions and presumably potential exposures (as with the community-based air toxics reporting), and still others broadly indicative of "environmental health" (as with the EPA Environmental Indicators Initiative). Other organizations have similarly developed indicators of progress toward sustainable development, including the use of specific quantifiable goals for reduction of greenhouse gases, water conservation, fleet fuel efficiency, reduction in air carcinogen release, and independent verification of the effectiveness of environmental management goals. The UN System, for example, includes 58 separate parameters that track social, environmental, and economic progress. Once all the metrics are in place, the next challenge will be to understand whether these various indicators together measure progress towards a more sustainable economy and environment.

Understanding the extent to which specific actions have enhanced sustainable development will require accounting for both economic and social improvements, as well as environmental impacts, similar to life cycle analysis. The challenge to such analyses involves bounding the analysis so as to make the process manageable, while not restricting it so as to yield answers that can be misleading. Consider the simple example of the energy sustainability of providing drinking water – either through a faucet or from a plastic bottle (see figure). When treatment, packaging, and transport are taken into account, the bottled water yields a much greater energy impact (more than 100-fold), and is considered overall less sustainable than tap water. This particular analysis is valid only within the boundaries defined. For example, how would the results differ if the cost of washing glasses *vs.* disposal of plastic bottles were included in the analysis or if the bottles were recycled to other products?

Clearly, there are many challenges to incorporating sustainability into products and processes. But, the potential

continued on pg. 4

Energy Costs for One Liter of Water



Implications of a Cap-And-Trade System for Reducing Greenhouse Gas Emissions

By Neal C. Grasso, M.S.

As the need to reduce greenhouse gasses becomes more apparent, legislative and economic systems are emerging to help make such reductions a reality.

Implementation of a U.S. greenhouse gas emissions reduction program will likely occur within the next few years. Seven proposals have been introduced in the 110th Congress aimed at reducing greenhouse gas emissions anywhere from 70% below 2005 levels by 2050, to 80% below 1990 levels by 2050. Initiatives also are underway in the Northeast through the Regional Greenhouse Gas Initiative and in the Northwest through the Western Regional Climate Action Initiative.

Despite the lack of regulatory consensus, the cost of emitting greenhouse gasses will increase in the near and long term.

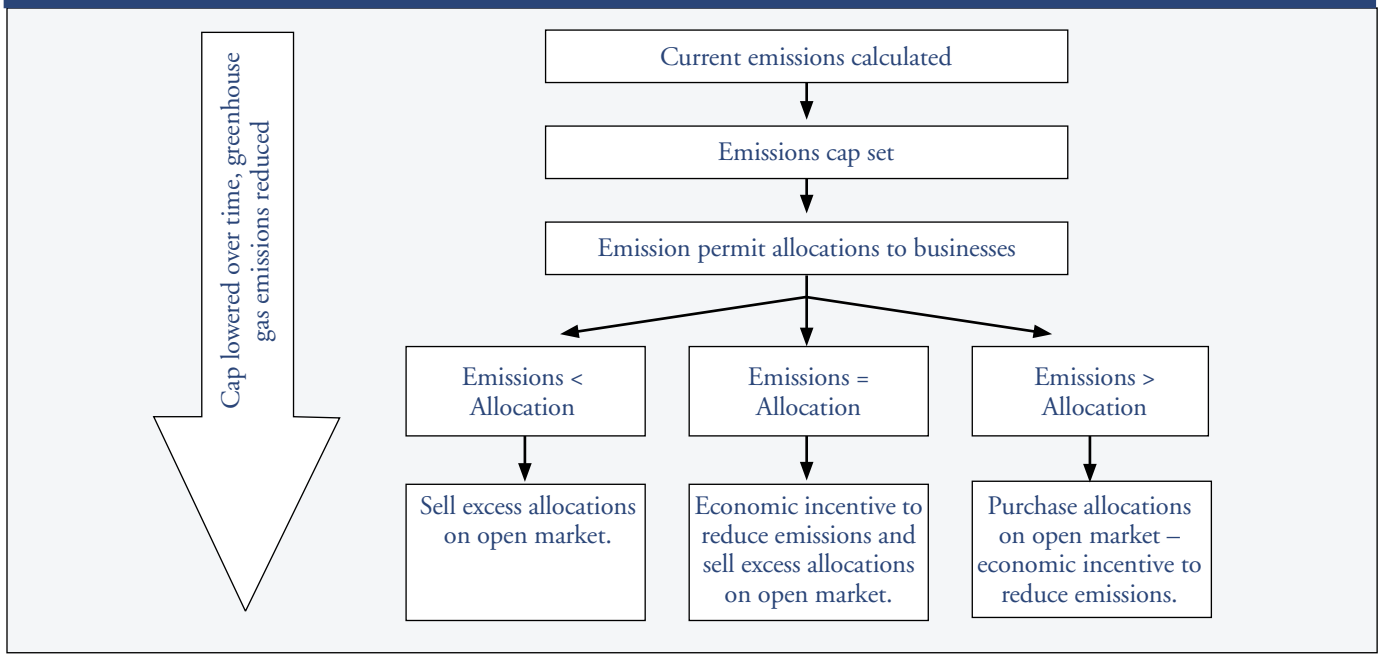
The common theme among the proposed plans and initiatives is the use of a cap-and-trade system to stimulate reduction of greenhouse gases. Under a cap-and-trade system, the government sets a cap on emissions from a designated group of emitters. Allowable emissions are then divided into individual permits, which are allocated to businesses covered under the program. Since the number of permits is limited by the cap, permits take on a financial value and can be traded on the open market. While market incentives encourage them to do so at the lowest possible cost, businesses can customize their own approach to emissions reductions. When introduced, the cap is set high, then gradually lowered to achieve the desired pollution reduction goal, giving businesses time to adjust their mitigation strategies to comply with new requirements.

The Congressional Committee on Energy and Commerce (CEC) recently prepared a white paper modeling proposed legislation for a greenhouse gas cap-and-trade program. In the model, regulation would occur at points along the economic stream that result in greenhouse gas emissions. For instance, electricity generators and industrial sources could be regulated directly, while refiners and importers could be the point of regulation for the transportation sector. In addition, the report suggests that cap-and-trade alone may not be sufficient to achieve objectives; a change in tax policy also may be required.

A tax policy change would likely mean a tax imposed on fossil-fuel suppliers at a rate reflecting the quantity of greenhouse gas emissions likely to occur when fuel is combusted. By raising the cost of produced energy, the tax theoretically stimulates demand for energy-efficient products, promoting cleaner fuels

continued on pg. 5

How a Cap and Trade Program Works



GRADIENT TRENDS
Risk Science & Application

Alternatives to Fossil Fuels

By Elizabeth A. Allen

The rising costs of depletable resources are leading to renewed interest in a variety of alternative energy sources.

Current consumption of coal, oil, natural gas and other finite resources will ultimately prove to be unsustainable. But, as the pressure mounts to find sustainable alternatives, a cast of both "old school" and "new age" technologies are emerging.

Solar energy either harnesses photovoltaic technology to produce electricity, or heats steam *via* solar-thermal technology to power generators. Both methods produce negligible air pollution and/or solid waste. Solar's light environmental impact and nationwide availability are offset by intermittent access to sun and the possible encroachment of large arrays on animal habitats. Improvements in panel efficiency and storage mechanisms can make solar an alternative to, or a component of, existing systems.

…as the pressure mounts to find sustainable alternatives, a cast of both "old school" and "new age" technologies are emerging.

Wind power, using turbines to carry moving air's energy to generators, functions best in the strong, consistent air flow of the Great Plains and Rockies. Emissions and land footprint are small, but wind has drawbacks similar to solar power, in that they both depend on a variable (or inconsistent) resource. Although some object to turbines' unsightliness and noise, turbines are successfully installed in many locations. However, improperly installed turbines could contribute to soil erosion and the turbine blades themselves to avian deaths.

Geothermal energy taps the movement of molten rock beneath the earth's crust, using the heat and hot water to heat structures directly, or to power electric turbines. Accessible where geothermal activity occurs near the surface (*e.g.*, in Yellowstone National Park, Wyoming) or where deep drilling is done, geothermal sources can provide reliable energy with a relatively small impact to the land. Yet geothermal plants release CO_2 and hydrogen sulfide, both of which promote global warming.

Hydropower has long been used to exploit water's downhill movement through dams to run electricity-generating turbines. Available more widely than solar or wind, hydropower is convenient, relatively inexpensive, and supported by current infrastructure. However, reservoir creation for hydropower can impact both aquatic and terrestrial ecosystems and change seasonal water level fluctuations vital to the survival of some species. While hydropower itself offers nearly emission-free energy, the energy cost to construct and maintain sophisticated hydropower plants is considerable.

Biofuels, such as ethanol and biodiesel, are derived through the fermentation of agricultural crops – usually corn. They emit only the atmospheric CO_2 used in their production, thus not contributing to global warming. Furthermore, most current engine technologies can be easily adapted to run on biofuels. The vast acreage required could mean less land for food crops and human habitation, but the corn industry asserts that excess acreage is actually available. Pimentel and Patzek (2005) suggest that biofuel manufacture from corn, soybeans, and wood could use more energy than it yields. However, switchgrass may be a less energy intensive alternative, since it would not impact food supplies, does not require pesticides, and grows in marginal areas unsuitable for other crops.

Nuclear energy uses controlled nuclear fission to release heat to drive steam turbines. Nuclear power often sparks fears of contamination accidents or the repurpose of waste in weaponry. But much of used uranium can be recycled in new fuel. Nuclear power, used successfully for decades in Europe, provides massive amounts of inexpensive energy with minimal contribution to global warming.

All energy sources, both alternative and traditional, have their strengths and tradeoffs. There may be no single substitute for fossil fuels in the near term. But, the power sources mentioned above hold promise – especially if used collectively in systems that balance their benefits with their potential environmental impacts.

The author can be reached at eallen@gradientcorp.com.

References:

Pimentel, D. and T. Patzek. 2005. Ethanol production using corn, switchgrass, and wood: biodiesel production using soybean and sunflower. *Nat. Resources Res.* 14(1):65-76.

Sustainability: An Overview

continued from pg. 2

long-term advantages to making this concept a reality seem to make the view worth the climb.

The author can be reached at bbeck@gradientcorp.com.

References:

World Commission on Environment and Development. 1987. "Our Common Future [The Brundtland Report]." Prepared for United Nations General Assembly. UN General Assembly document A/42/427.

What's New at Gradient

Recent Articles

Rhomberg, L.R., K. Baetcke, J. Blancato, J. Bus, S. Cohen, R. Conolly, R. Dixit, J. Doe, K. Ekelman, P. Fenner-Crisp, P. Harvey, D. Hattis, A. Jacobs, D. Jacobson-Kram, **T. Lewandowski,** R. Liteplo, O. Pelkonen, J. Rice, D. Somers, A. Turturro, W. West, and S. Olin. 2007. Issues in the design and interpretation of chronic toxicity and carcinogenicity studies in rodents: Approaches to dose selection. *Crit. Rev. Toxicol.* 37(9):729-837.

Rhomberg, L.R. and **J.E. Goodman.** 2007. Letter to the editor re: Restricting bisphenol A. *Chem. Eng. News* 85(24):6-7.

Upcoming Presentations

Seattle, WA. March 16-20, 2008. 47th Annual Meeting of the Society of Toxicology:

- **Leslie A. Beyer, Tracey M. Slayton, Julie E. Goodman, Grace I. Greenburg, Todd C. Hudson,** and **Barbara D. Beck.** "Evaluation of key information informing the basis of EPA's new recommended ozone standard."
- **David G. Dodge,** L.T. Haber, E. Kopras, **Julie E. Goodman,** I. Pagan, J.S. Gift, and **Lorenz R. Rhomberg.** "Case studies for the development of a pathophysiological progression model."
- **Julie E. Goodman, Lisa A. Bailey,** and **Barbara D. Beck.** "Recent studies of the health effects of manganese and the implications for the reference concentration (RfC)."
- **Ari S. Lewis, Leslie A. Beyer,** and **Barbara D. Beck.** "Evaluating the toxicological significance of endpoints from human and animal studies: Using perfluorinated compounds (PFCs) as an example."
- **Rosemary L. Mattuck** and **Teresa S. Bowers.** "Examination of the current geographic relationship between blood lead levels and air lead levels in the United States."
- **Lorenz R. Rhomberg.** "Acute inhalation toxicity: Physiological time and species-specific half-life as determinants of animal-to-human extrapolation of toxicologically equivalent combinations of air concentration and duration."

Implications of a Cap-And-Trade System for Reducing Greenhouse Gas Emissions

continued from pg. 3

and renewable energy. Like the cap-and-trade program, the carbon tax would be gradually introduced so that prices of fossil-fuel energy would rise slowly, thus theoretically minimizing deleterious economic effects.

Proponents of cap-and-trade point to the system's success in reducing emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and related pollutants emitted from U.S. power plants. In addition, members of the United States Climate Action Partnership (USCAP), an alliance of businesses and environmental groups promoting greenhouse gas reduction legislation that requires significant reductions of greenhouse gas emissions, prefer cap-and-trade because it is flexible, adaptable to market changes, and is the most politically feasible approach.

Opponents claim that cap-and-trade is too complicated, includes potential loopholes, and would cause volatility in energy production costs. Advocates counter that, when combined with a carbon tax, these loopholes can be eliminated, and long-term energy prices would be more predictable. This position increases the likelihood that any successful program would include a cap-and-trade program coupled with a carbon tax.

Despite the lack of regulatory consensus, the cost of emitting greenhouse gasses will increase in the near and long term. To comply with expected regulatory requirements, businesses will need to reduce emissions through improved energy efficiencies and conservation, increased reliance on renewable energy sources and nuclear energy, and development of innovative technologies such as carbon capture and storage. Cap-and-trade proponents believe that these adaptations will not occur without such regulation.

The author can be reached at ngrasso@gradientcorp.com.

For Additional Information:

Committee on Energy and Commerce (CEC). 2007. Climate Change Legislation Design White Paper: Scope of a Cap-and-Trade Program. United States Congress, October.

U.S. Climate Action Partnership (USCAP). 2007. A Call for Action: Consensus Principles and Recommendations. http://www.us-cap.org/.

U.S. EPA. 2003. Tools of the Trade: A Guide To Designing and Operating a Cap and Trade Program For Pollution Control. Office of Air and Radiation, EPA430-B-03-002, June. www.epa.gov/airmarkets.

Guest Editorial: The Role of Sustainability in Remedy Selection

By David E. Ellis, Ph.D.

Elements of sustainability can result in more beneficial remedies – if we let them.

Sustainability, long the darling concept of business schools everywhere, and more recently the battle cry of virtually the entire corporate world, is seeing new opportunity as a decision criterion in waste site remedy selection.

Getting to a process where remedies are selected based on a consideration of sustainability will require a change in thinking on the part of both the regulatory and regulated communities.

For decades, the process of remedy selection has sought to identify a remedy that can improve the quality of a soil or groundwater situation, with little regard for impacts on air quality or consumption of natural resources. This compartmentalized approach to environmental remediation may have satisfied the public demand for environmental accountability. Today, however, in the era of global warming and carbon counting, a greener public might be ready to ask for more sustainable clean-ups.

Getting to a process where remedies are selected based on a consideration of sustainability will require a change in thinking on the part of both the regulatory and regulated communities. The first step for environmental oversight agencies across the United States is to acknowledge that even the most meticulously executed remediation can itself be a source of pollution. While a few in the regulatory community are studying the idea of sustainable remediation, most agencies do not even calculate the carbon and particulate emissions that result from environmental clean-ups. The second step – and it is a big one – would be for regulators at all levels to develop new decision criteria for selecting and overseeing environmental clean-ups. The criteria need to be holistic and must assess not only the current damage to soil and ground water, but also the damage that implementing a remedy might cause to the air or surface water.

As for those responsible for paying for the clean-ups, they must embrace several key sustainable remediation principles so that the remedy provides the greatest net benefit to the environment. First, remedies should minimize or eliminate the consumption of energy or other natural resources. Second, they must reduce or eliminate releases to the environment – especially the air. Next, they should mimic or harness a natural process. And they should strive to reuse or recycle land or other resources. Finally, they must encourage the use of remedial technologies that permanently eliminate the threat of the contaminants.

None of these steps will be easy. They will require a sea change in thinking among all parties involved. But, ultimately, embracing sustainability concepts in remediation has enormous potential to result in net gains in environmental quality – not merely shifting pollution from one medium to the next.

The author is the Manager of Technology Development at DuPont CRG.

By The Way...

According to the Chinese government, since China introduced stringent birth control measures in the late 1970s, over 300 million births have been forestalled, along with the emission of 1.3 billion tons of CO_2 in 2005. Thus, in the estimation of the Chinese government, the one-child policy is an environmentally friendly means of preventing climate change.

Source: Alertnet.org, 2007. http://www.alertnet.org/thenews/newsdesk/L30472039.htm.

In the next issue:

Look for *Trends* on the Web at: www.gradientcorp.com

GRADIENT TRENDS
Risk Science & Application

Produced by:
Gradient Corporation
20 University Road
Cambridge, Massachusetts 02138
Phone: (617) 395-5000
Fax: (617) 395-5001
Internet: trends@gradientcorp.com

Printed on recycled paper with soy inks