"ECOBALANCE": A TOOL FOR ENVIRONMENTAL FINANCIAL MANAGEMENT

A managerial tool developed in Germany offers a new pathway to P2

Mark A. White and Bernd Wagner

Environmental issues are a growing strategic concern for businesses in both the United States and Europe. Rising consumer sentiment, increasingly stringent governmental regulations, and skyrocketing costs for pollution control and waste disposal are affecting the competitive position of firms on both sides of the Atlantic. During the past few years, several firms in Germany have responded to these challenges with a new managerial tool—the "ecobalance."

In many aspects similar to the American concepts of environmental auditing and environmental reporting, ecobalances also incorporate aspects of product life-cycle analysis. As such, they offer a useful method for evaluating environmental impacts for purposes of pollution prevention, bridging the gap between standard accounting practice (in which data are expressed solely in monetary terms) and qualitative environmental reporting.

This article discusses the use of the German "ecobalance" as a managerial tool for pollution prevention and environmental financial management. The article first provides a brief historical review of the ecobalance approach and differentiates it from other instruments used for similar purposes. It then details how to conduct an ecobalance analysis and discusses various methods for interpreting the results. The article concludes with reflections on the usefulness of the ecobalance to American firms.

Background: Environmentalism in Germany

In comparison to the United States, Germany is a small country, about the size of Michigan and Ohio in area. Germany's population is also much smaller than that of the United States, but its population density is almost ten times higher. Thus, Germans tend to be more aware of, and demonstrate greater concern about, environmental issues than Americans. A recent poll by *Focus* magazine asked citizens of many countries to prioritize the problems they were "most worried about." In Germany, 67 percent listed the environment as their

CCC 1079-0276/96/060231-14

top concern.[1] In the United States, the environment ranked third (tied with racism and unemployment), receiving a support rating of 34 percent.

Germany has a history of environmental activism, a well-established Green political party, and extremely stringent environmental laws. Its residents spend a larger percentage of their gross domestic product (GDP) on environmental protection than any other nation in the world.[2]

What Is an Ecobalance?

The "ecobalance" is a structured method for reporting the physical inflows and outflows of resources, raw materials, energy, products, and wastes occurring within a particular organization during a specified period of time.[3] As such, it has similarities to the "mass and energy balance" approach often used in the United States.

Preparing an ecobalance involves posing questions rarely asked before.

In an ecobalance, data are collected and reported in a number of physical units, such as pounds, gallons, square meters (or feet), and kilowatt-hours, which increases flexibility and speeds implementation. Preparation of an ecobalance assists a firm in identifying opportunities for pollution prevention and cost savings, prioritizing these opportunities for later implementation, and measuring the performance of pollution prevention efforts.

An ecobalance is constructed from three major components: the organization (or firm) balance, the process balance, and the product balance (Exhibit 1). The "organization balance" encompasses all of the energy and materials going into and coming out of the entire firm over the course of a year. "Process balances" provide an overview of resource and energy use in specific production processes. "Product balances" are prepared to assist management in determining the environmental impact of particular product lines. Together, these three components make up a firm's ecobalance.

Benefiting from the Ecobalance Approach: The Experience of German Firms

German firms were among the first to pioneer the ecobalance concept, and they have enjoyed a variety of benefits from it.

For example, Staatliche Mineralbrunnens Bad Brückenau, a major bottler of natural mineral waters in middle Germany, is concerned with both reducing costs and protecting natural resources. By keeping better track of water and detergent use, the firm has reduced its materials and waste disposal costs while safeguarding its primary source of supply.

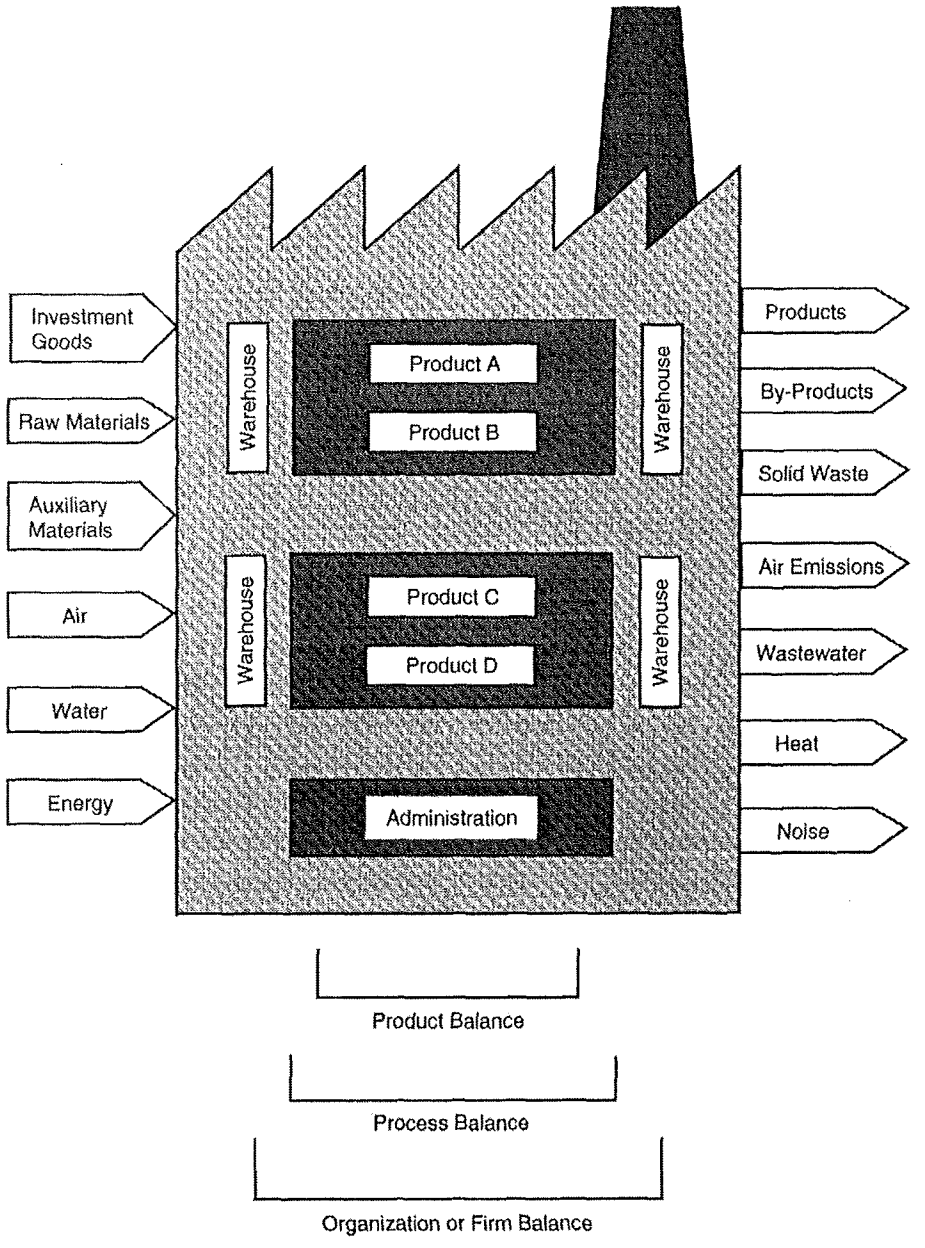
Lammsbräu, a family-owned beer brewery in northern Bavaria, prepared its comprehensive ecobalance as part of an overall strategy to dominate the small but growing market for "eco-beer" in Germany.

Kunert AG, Europe's largest manufacturer of nylon stockings, discovered an enormous shortfall between annual water inputs and outputs during the course of preparing its first ecobalance in 1991. An in-depth investigation revealed a leak deep beneath the firm's manufacturing plant which had existed for more than ten years![4]

Today, many large European firms—including Siemens, Volkswagen, Allianz Versicherung, Sanyo, Ciba Geigy, and Swissair—are using ecobalances for controlling purposes.

Preparing an ecobalance involves posing questions rarely asked before. And often, expressing data in physical units generates new insights. For instance, managers at a bank in southern Germany wondered about fluctuations in total energy use among their 241 branches. While conducting an ecobalance analysis, data were collected on the total area of each affiliate facility. Comparing these figures against the individual utility bills revealed

Exhibit 1. Component Parts of an Ecobalance



large differences in the energy efficiency among the various branches.

Development of the Ecobalance Concept

The early roots of ecobalance analysis can be traced to the concept of "ecological accounting," developed in the 1970s by Ruedi Müller-Wenk,[5] which is based on the notion that products whose manufacture entails higher environmental costs should carry higher prices. Envisioning that departments would eventually be held accountable for their environmental as well as their financial

budgets, Müller-Wenk developed a set of accounts to measure what were then considered to be the environmental impacts of greatest concern.

Although difficult to implement in practice, the concept of an ecological accounting did stimulate European researchers to develop other methods for evaluating a firm's environmental performance.

Eco-Profiles and LCA

One line of inquiry focused on assessing the impact of different materials and resources used in a product's manufacture. Swiss researchers developed a method to compare the effects of competing packaging technologies based on "critical thresholds" for environmental damage.[6] Results were expressed as "eco-profiles"—small bar charts illustrating the energy use, air emissions, water emissions, and volume of solid waste resulting from each technology under investigation. This system has since been refined by combining all of a product's environmental impacts into a single dimension, the so-called "eco-points."[7]

Another branch of investigation sought to trace a product's use of natural resources and energy throughout all stages of its life. In the United States, attempts to compare products and processes on the basis of energy and resource flows date back to the late 1960s.[8] A few such studies were carried out in the 1970s, including Franklin Associates' work on beverage containers[9] and Arthur D. Little's study of disposable versus cloth diapers.[10] But research in this area decreased as public interest in environmental issues faded during the late 1970s.

These studies took into account a wide range of environmental effects, from resource extraction and refining to manufacturing, transportation, use, and disposal.

When a renewed wave of environmental consciousness manifested itself in the late 1980s, studies investigating the environmental impact of products over their entire life cycle came into vogue. These studies took into account a wide range of environmental effects, from resource extraction and refining to manufacturing, transportation, use, and disposal. The recommendations of these "cradle to grave" (or "womb to tomb") studies were not always heeded, however. And public perceptions sometimes dictated results that were contradicted by their findings. For instance, McDonald's was forced to stop packaging its hamburgers in polystyrene "clamshells" despite evidence that polystyrene packaging was actually *less* harmful to the environment than paper wrapping.[11]

Despite the problems, this form of analysis, usually called "product line analysis" (PLA) or "life-cycle analysis" (LCA), continues to flourish in both the United States and Europe.[12] Two U.S. organizations, Green Seal and Scientific Certification Systems, issue environmental product evaluations based in part on this method.

Ecobalance Emerges

A more ambitious project designed to measure environmental impacts on a "whole firm" basis was begun in the late 1980s at the Institut für Ökologische Wirtschaftsforschung (Institute for Environmental Economic Research, or IÖW) in Berlin. There, researchers developed an ecobalance concept consisting of three sub-balances (not necessarily nested within one another), combined with a life-cycle analysis of all the firm's major products.[13]

Over the past several years, a number of researchers have made alterations or adjustments to this basic model.[14] Kunert AG was the first company to make its ecobalance analysis available to the general public.

Product Tree Analysis

Product life cycles are frequently represented as a straight line running from extraction of raw materials through product disposal. The problem

with this representation is that manufacturing processes are rarely linear. Kunert AG's ecobalance abandoned the product life-cycle concept, substituting "product tree analysis." This approach is now at the heart of the ecobalance concept.

Product tree analysis offers certain advantages in understanding a firm's input and output functions and helps reduce complexity. In this approach, the firm's production process is not viewed as a straight line, but rather as a tree. **Exhibit 2** shows a simplified product tree for prepackaged fruit yogurt.

Initial inputs of land, energy, and raw materials might be likened to a tree's tangled roots, weaving in and about each other while creating secondary materials for use in a variety of later products and processes. The actual production takes place in the tree's trunk. Multiple divisions are easily characterized by forked or split trunks. The tree's branches yield both desirable fruits (products and services) and undesirable remnants (such as air emissions, wastewater, and waste heat).

The decentralized, "spreading" nature of some firms bears more than a little resemblance to a tree's canopy. But perhaps the greatest strength of this metaphor is that it does not require one to devote equal attention to all branches. Managers often already know which products and processes consume the greatest resources—and they certainly know which ones contribute the most to the company's overall success. Focusing on the most important pathways first improves the project's manageability while preserving the overall structure of the analysis.

Performing an Ecobalance Study

Successful implementation of an ecobalance program requires cooperation at all levels of the organization. It should be made clear from the beginning that the project is not being undertaken solely for ethical or moral reasons, but rather to identify possibilities for strategic advantage.

Management Support/Steering Committee

An environmentally concerned organization undertaking an ecobalance study might structure its activities as shown in **Exhibit 3**. The discussion below explains how this structure would work in practice.

Support from the highest levels of management is necessary to establish the project's importance and open nontraditional lines of communication. A steering committee or supervisory council composed of department heads, environmental specialists, and often an external consultant should be responsible for overseeing the processes of data collection and analysis and deciding on implementation programs based on the study's recommendations. This council would also be responsible for coordinating information needs and for key decision variables—such as deciding which product lines should be followed to their "roots" and which should receive more cursory treatment.

The work group should have a direct contact to upper management.

Work Group/Eco-Teams

The ecobalance work group or "green team" is composed of representatives from all relevant functional areas—such as controlling, research and development, purchasing, production, marketing, finance, strategic planning, product design, quality control, health and safety, and personnel. The work group should have a direct contact to upper management, perhaps via a staff assistant to the Chief Executive Officer.

Responsibilities of the ecobalance work group would include:

- Developing the overall concept, including construction of the various accounts and structuring the ecobalance sheet;
- Collecting data (in cooperation with the respective functional areas);

Exhibit 2. Product Tree Analysis for Fruit Yogurt

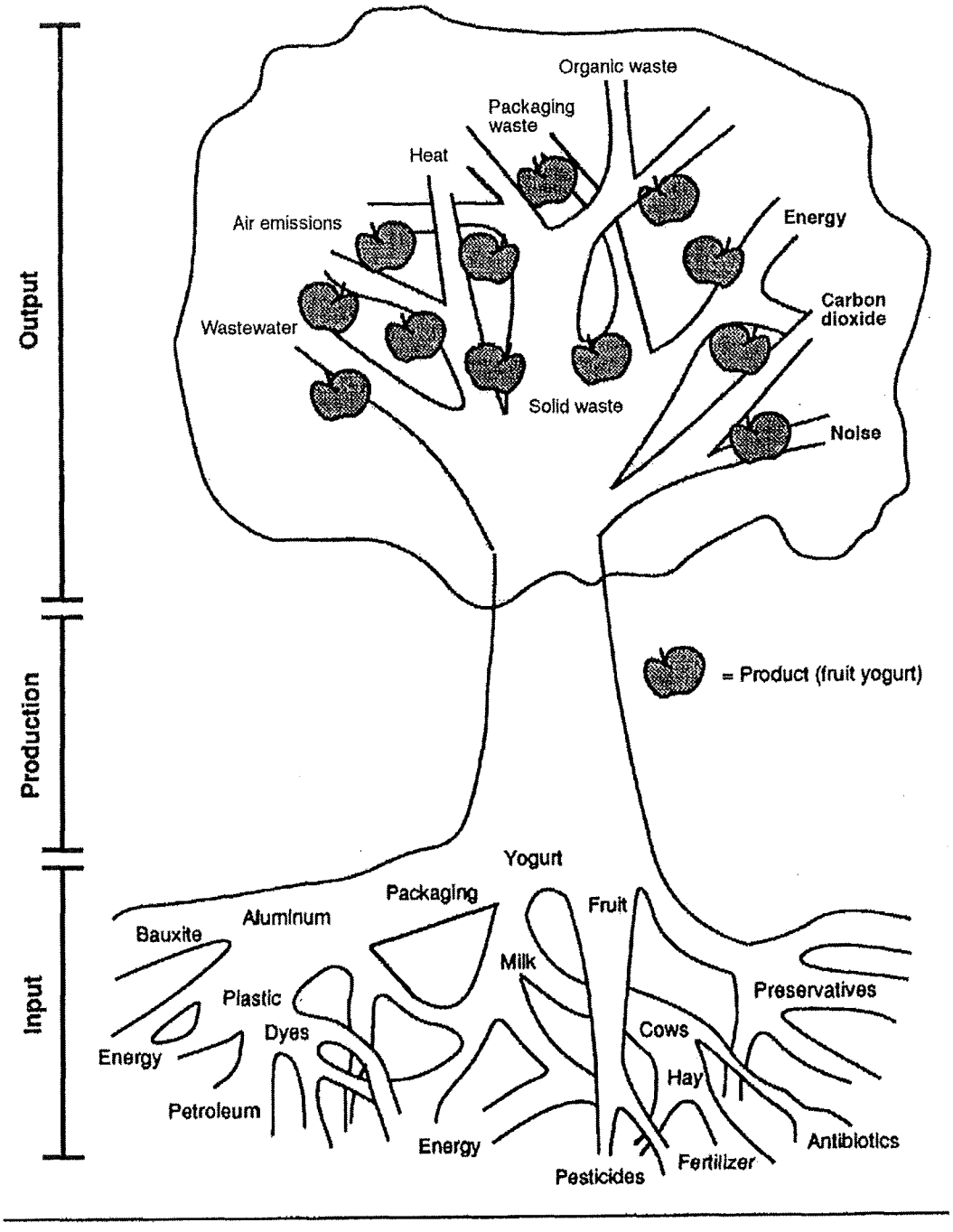
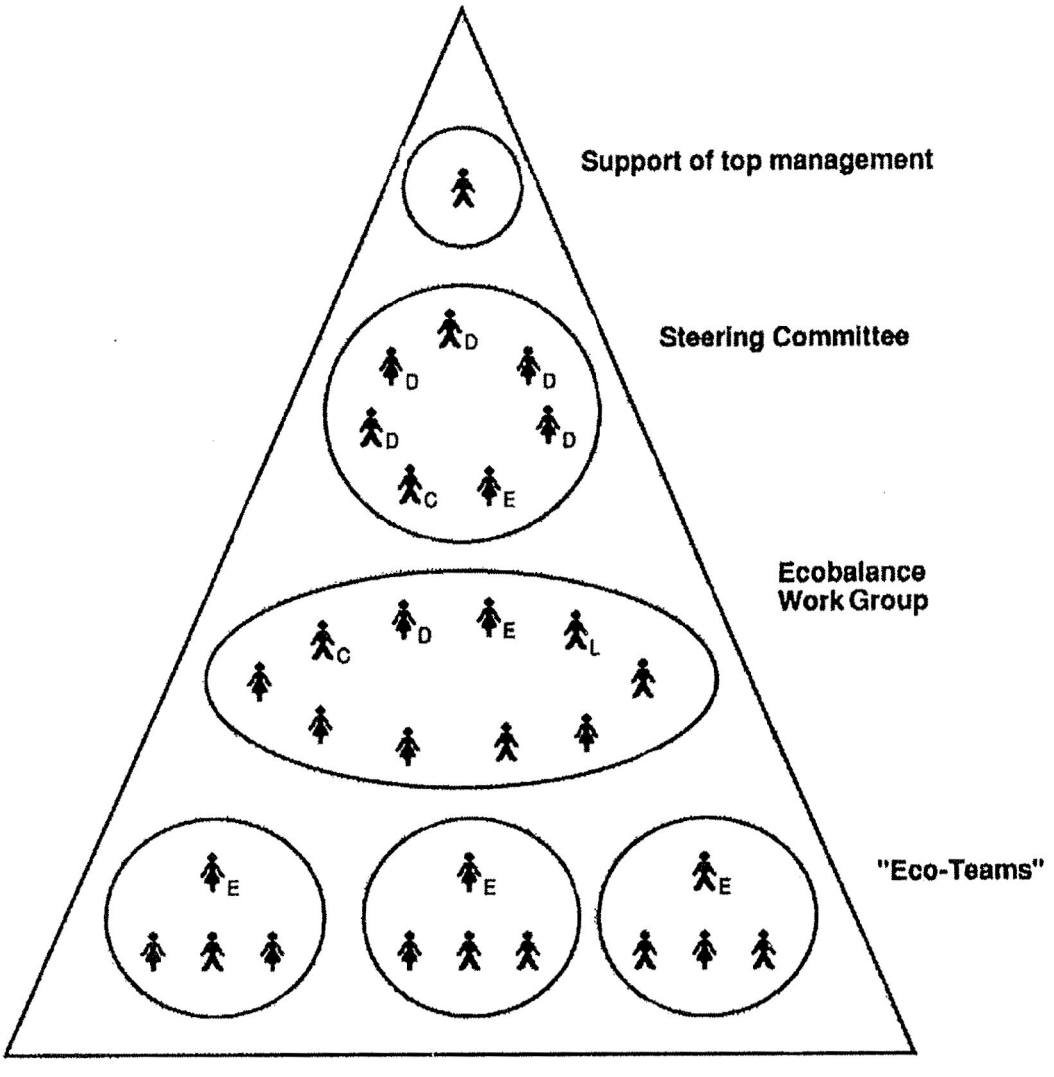


Exhibit 3. Organizational Structure for Performing an Ecobalance



- Setting priorities, analyzing strengths and weaknesses in particular areas of interest, and locating risks and savings potentials;
- Analyzing results and developing measurable goals; and
- Preparing the final balance and commentary.

The work group should strive at all times to maintain open communication among the various interested parties and functional areas. In fact, this is one of the major benefits of conducting an ecobalance study: It provides a cross-functional forum for discussing opportunities to improve environmental performance and reduce costs. It may be helpful to hold a seminar at the start of the project describing its goals and information needs.

The project must be manageable.

Sometimes it will be necessary to contact external experts for assistance with technical data, such as waste disposal alternatives, preproduction processes, or energy alternatives. In these cases, special project teams (or "eco-teams") may be created, supplemented by technical specialists from within the firm.

After the study is completed, its recommendations and results should be diffused throughout the organization.

Cost and Time Required

The entire project can be completed in 6 to 12 months, assuming the team meets every four to six weeks for a half-day or day. The study's costs include the work group's time, consultants' fees, and miscellaneous administrative support costs.

These costs generally can be more than offset by the potential savings the study identifies in areas such as energy and water conservation, reduction of packaging, waste minimization, and materials substitution.[15] Based on the results of its first ecobalance study, Kunert AG invested DM 300,000 in constructing a system to recover waste heat. The investment returned an additional DM 2 million over the first two years it was operational and now saves approximately one million liters of heating oil per year.

Setting Goals and Boundaries

It is inevitable that organizations conducting an ecobalance analysis for the first time will experience difficulties in determining what items should be included and how these items should be measured. Many misunderstandings can be avoided, however, by carefully specifying the project's goals and boundaries beforehand.

Perhaps the first issue to be resolved concerns the study's intended audience and/or purpose. Is it primarily for internal use, as a management tool, or will it be used to provide information to outside parties, or perhaps in marketing efforts? If the study is for internal use, technical details and sources for additional information are likely to be included. If the study is to be disseminated outside the firm, special care should be taken to avoid misperceptions and miscommunications.

Second, the project must be manageable. Too large a scope places a heavy burden on scarce company resources and may cause a project to collapse under the weight of its own data. It is much better to start small and add departments or divisions as experience is gained.

In most organizations, certain processes and products ("trunks" and "fruits" in the product tree analysis vocabulary) will carry a priority interest. Excluding less critical areas saves resources and allows teams to concentrate on more important spots. For instance, in its first report, Swissair chose to examine all environmental impacts arising from company activities at the Zürich airport. But in analyzing the effects of international operations, the company restricted its efforts in order to make the project more manageable. In this case, Swissair chose to analyze the effects of airplanes alone, ignoring the impacts caused by personnel, energy use, and ground transport.

Differences of opinion exist with regard to what should be included in an ecobalance analysis. In analyzing the production of yogurt from

cow's milk, for example, is it necessary to include the fertilizer and pesticides used to grow hay for the cows? Should an ecobalance for a brewery include deaths from drunk driving or adverse health effects stemming from the use of alcohol?

In some respects, the answer depends on the intended audience and the use to which the resulting report will be put. McDonald's Restaurants (Suisse) widely publicized the results of a study comparing the impacts of its restaurants with other establishments in Switzerland. In each category examined—energy use, water use, and food waste—McDonald's emerged the clear winner.[16]

Certainly, good arguments can be mustered for stopping the analysis at the doors of the organization, for this is where management exerts its strongest influence. However, it is also important to keep in mind the broader interests and desires of society. If, for instance, recycling is widely valued, it makes sense to measure and emphasize the extent to which the company recycles waste or buys recycled materials. McDonald's USA is a leader in this area, committing itself to the purchase of recycled materials for its restaurants wherever possible.

Finally, regardless of audience, it is best to insist on a high standard of rigor from the beginning. Assumptions and calculations should be clearly stated or made available upon request. If no reliable estimate for a particular parameter is available, that account should be left blank until it is determined to be of sufficient importance to invest resources in obtaining more trustworthy figures.

Data Collection and Presentation

In collecting data, a first step is to set up organization-wide "accounts" for the areas to be analyzed. An input-output scheme can specify the major areas of interest, such as air emissions and energy use. The five major categories of inputs are

- Raw/auxiliary materials and noncapital goods
- Investment (i.e., capital goods)
- Water
- Air
- Energy

Corresponding output accounts are

- Products
- Solid waste
- Wastewater
- Air emissions
- Energy losses (e.g., heat and noise)

In all probability, it will prove impossible to collect data for some accounts, such as air inputs and noise. Their presence on the balance sheet serves as a useful reminder, however, of areas for improvement.

Specific details of the accounts will differ from firm to firm. As an example, an input-output balance sheet for the internationally operating German machinery manufacturer Voith is shown in **Exhibit 4.**

Because the ecobalance method is still in its infancy, there are numerous variations on this basic theme. **Exhibit 5** presents a general structure for treating the accounts in an ecobalance statement.

Most firms will find it useful to begin constructing the necessary management information systems early on.

Cross-sectional comparisons of resource use and/or emissions on a per-unit or functional basis can be made immediately upon preparation of the firm's first ecobalance. Temporal comparisons within departments or against specific benchmarks are possible after a firm has gained experience with this method. In either case, most firms will find it useful to begin constructing the necessary management information systems early on.

Exhibit 4. Input-Output Balance Sheet for a Manufacturer

Input	91/92	92/93	Output	91/92	92/93
1. Material (tons)	**66,951**	**50,107**	**1. Products (tons)**	**38,068**	**39,863**
1.1 Production material	29,954	19,296	1.1 Paper/material technology	18,046	19,609
1.2 Additional material not differentiated	20,405 21,592	30,416 395	1.2 Propeller technology 1.3 Electrical technology 1.4 Foundry	8,548 5,670 5,804	7,736 5,874 6,644
2. Investment (pieces)	**1,678**	**591**			
2.1 Buildings	0	0	**2. Refuse**		
2.2 Technical equipment	1,609	551	2.1 Investment waste (pieces)	238	700
2.3 Parking lots	69	40	2.2 Recoverables (tons)	13,981	13,833
			2.3 Waste (tons)	28,501	1,101
3. Water (m^3)	**8,434,157**	**8,825,165**	2.4 Soil removal (tons)		722
3.1 Drinking water	1,187,137	1,163,851			
3.2 Production water	6,937,493	7,346,772	**3. Wastewater (m^3)**		
3.3 Rain water	309,527	314,542	3.2 Amount (m^3)	8,434,157	8,825,165
			3.2 Pollution		
4. Air					
4.1 Amount			**4. Air emissions**		
4.2 Pollution			4.1 Amount		
			4.2 Pollution		
5. Energy (MWh)	**304,938**	**291,788**			
5.1 Natural gas (Hu)	242,079	259,648	**5. Energy use (MWh)**	**304,938**	**291,788**
5.2 Heating oil (Hu)	39,210	9,937	5.1 Electricity	2,594	1,953
5.3 Electricity	19,857	19,162	5.2 Steam	26,817	30,221
5.4 Fuel (Hu)	3,792	3,041	5.3 Remaining energy	275,527	259,614

Source: J.M. Voith GmbH, *Der Umweltbericht 1992/93*

Analyzing Ecobalance Results

An ecobalance is a management tool. It can be used as an environmental rallying point and as a way of improving the flow of information throughout the firm. But using it effectively means analyzing the data that have been gathered.

Several kinds of analysis may be performed. Initial analysis may focus on what has most likely been an ongoing question throughout the data-gathering phase: Where are all the inputs going? And where are the outputs, particularly the hazardous ones, coming from? Even after the green team's best efforts, there are still likely to be discrepancies between inputs and outputs. Identifying the causes of these discrepancies can yield interesting results, as happened in the case of Kunert's missing water supply.

Focusing on Key Areas

Focusing on the biggest "branches" first can help a firm direct its pollution prevention efforts. In this respect, the Kunert corporation is again the source of an interesting anecdote. The firm had run into trouble with the level of chromium in its wastewater and was planning to build a new treatment plant to bring its emissions back into compliance. As part of its routine data collection process, the ecobalance team asked Kunert's dye department to identify the quantity and hazardous characteristics of the company's dyes, which numbered in the hundreds. The dye department initially balked at this request. But upon closer inspection, it was found that a single black dyestuff accounted for the vast majority of all dyes used—and that dye contained the chromium.

A suggestion to reformulate the dye was not well received, but the dye department went to work on the problem in cooperation with the production department. Eventually, the dye engineers were successful. The new dye contained no chromium, worked just as well as the old dye, and was cheaper to produce.

The reformulation of this one dye made it unnecessary for Kunert to build a new waste treatment plant. Without the ecobalance program as its impetus, it is unlikely the firm would have hit on this pollution prevention solution as soon as it did—in fact, in all likelihood, the firm would now have a new treatment plant.

Exhibit 5. General Structure of an Ecobalance

1. **Data Section** (figures, facts, and numbers)
   - Consolidated accounts
   - Individual accounts
2. **Evaluation Section**
   - Explanation and interpretation
   - Data description, analysis of strengths and weaknesses
3. **Goal-Setting**
   - Goals
     1. Absolute goals (zero emissions of substance *z* by time *t*)
     2. Relative goals (*x*% decrease by time *t*)
   - Activities to achieve goals

Appendix - Derivation of Measurements

Other Methods of Analysis

Other methods of analyzing ecobalance data include activity-based costing (ABC) analysis, environmental ratio analysis, and environmental cost accounting or "eco-controlling."

ABC analysis is a common technique in inventory control systems, but a relatively new idea in environmental management.[17] It involves assigning costs to the specific activities that give rise to them (rather than to overhead), and then using the resulting totals to prioritize environmental problems. This method allows firms to focus first on those pollution prevention opportunities with the greatest benefit-to-cost ratios—i.e., the "low-hanging fruit."[18] Such redistribution of overhead costs (especially energy and waste costs) can achieve significant differences in the way departments operate—in fact, one often need not demand change, but just ask for the data.

Environmental ratio analysis is akin to financial ratio analysis. It takes values from the completed ecobalance and reexpresses them in a different form for clearer presentation of information.[19] For example, following an advertising campaign in which Germany's Daimler Benz corporation touted the environmental virtues of its automobiles (specifically a glove box made from recycled paper), the environmental group Greenpeace reported that production of a 2.2-ton S-class Mercedes Benz generated approximately 52 tons of waste.[20] This is a production efficiency of 2.2 tons ÷ 54.2 tons, or about 4 percent. When presented this way, the environmental impacts of the automobile appeared much less benign. Ludwig Stocker Hofpfisterei, a large bakery in Munich, uses environmental ratio analysis to compute comparative resource demands for its major product (bread) on a per-unit basis (**Exhibit 6**).

Research to develop environmental cost accounting and eco-controlling systems is in progress in Germany[21] and elsewhere.[22] Researchers hope that such systems will encourage companies to expand investment decisions to include potentially hidden or contingent environmental costs. In the United States, EPA currently has a program underway to more fully identify and account for these kinds of costs.[23]

Benefits of an Ecobalance

Preparing and analyzing an ecobalance provides numerous benefits, particularly with respect to implementing and measuring programs for pollution prevention.

First, the results of an ecobalance allow a firm to identify environmental weak points, such as

Exhibit 6. Environmental Ratios for a Bakery

Energy use per loaf of bread	4.0 megajoules/kilogram
Water use per loaf of bread	1.2 liters/kilogram
Waste per loaf of bread	7.6 grams/kilogram
Carbon dioxide emissions per loaf of bread	245 grams/kilogram
Miles driven per loaf of bread	0.13 kilometer/kilogram

Source: Ludwig Stocker Hofpfisterei GmbH, *Ökobilanz 1991*

areas with high emissions or processes that generate unusually large amounts of waste. This information allows a company to develop its environmental strategies and reduce costs. In the early 1970s, for instance, Henkel, then Germany's largest manufacturer of phosphate detergents, recognized that its product was contributing to the eutrophication of fresh waters. As a result, Henkel slowly began reformulating its product line to be phosphate-free. The company is now the largest manufacturer of phosphate-free detergents in Germany and has made significant inroads into the French and British markets.

The ecobalance exercise itself is valuable as a method of fostering cross-departmental communication and providing a purpose for environmental dialogue. This is particularly important if management wishes to effect change. Before any significant transformation can occur, employees must internalize the *need* for change. Participation in gathering and analyzing ecobalance data can facilitate commitment. The ecobalance can be used as a focal point for increasing awareness of environmental issues throughout the corporation.

The ecobalance approach may also serve as a basis for certification under a number of programs designed to integrate pollution prevention and environmental responsibility into corporate decision-making processes. In June 1993, the European Union issued detailed guidelines for a voluntary ecomanagement and audit program. The International Standards Organisation is currently at work on ISO 14000, a set of environmental management guidelines similar to the well-known ISO 9000 quality standards. Many firms are likely to adopt these standards for market and competitive reasons, to gain favorable regulatory treatment, to improve their public image, and as a means of achieving environmental excellence.

A final possible application for ecobalance analysis is in the fledgling discipline of industrial ecology.[24] Using the natural environment as a model, this approach involves carefully tracking the inputs and outputs of various organizations and designing a closed system such that one firm's "wastes" are another firm's raw materials. For example, in Kalundborg, Denmark, waste steam from a coal-fired electricity plant is used in the production of pharmaceuticals, while excess heat is channeled to a nearby town and to warm the company's fish farm. Leftover fly ash from the company's scrubbers serves as the raw material for a plasterboard company. A conveniently located oil refinery exchanges natural gas and cooling water for waste steam from the electric utility, completing the loop.

Conclusion

By emphasizing inputs and outputs, eco-balances confront pollution problems head-on. They make clear that preventing pollution at the beginning of the pipe is often the wisest course of action because it simultaneously decreases resource use and avoids costly waste treatment or disposal.

As a managerial tool, ecobalance analysis provides the means for identifying environmental weak points, developing environmental strategies, reducing costs, and improving information flow—all of which may be expected to confer significant competitive advantage in financial and strategic planning processes.

Notes

1. E.G. Schwarz, "Am wenigsten Angst haben die Deutschen" [The Germans Have the Least Amount of Fear], *Focus* 45 (1993) pp. 48-50.

2. N. Husmann and J. Scherer, "Ökoinvestments sind noch grün hinter den Ohren" [Eco-Investments Are Still Green Behind the Ears], *Börse Online* 31 (1993) pp. 10-11, 14-16.

3. Unfortunately, there is currently a great deal of confusion regarding terminology in this area. The term "ecobalance" is also used for comparative analyses of materials, products, and technologies, although nothing really "balances" in these studies. For further discussion of this issue, see F. Rubik and T. Baumgartner, *Evaluation of Eco-Balances* (Commission of the European Communities, Brussels 1992).

4. The company was essentially paying twice for water it was not able to use—first as incoming (scarce) drinking water, and again as outgoing wastewater (because the latter's cost was calculated using input figures).

5. R. Müller-Wenk, *Die Ökologische Buchhaltung* [Ecological Bookkeeping] (Campus, Frankfurt/New York 1978).

6. Bundesamt für Umweltschutz (BUS), *Ökobilanzen von Packstoffen* [Ecobalances for Packaging Materials], Schriftenreihe Umweltschutz No. 24 (BUS, Bern 1984); Bundesamt für Umwelt, Wald und Landschaft (BUWAL), *Ökobilanzen von Packstoffen—Stand 1990* [Ecobalances for Packaging Materials—1990], Schriftenreihe Umwelt No. 132 (BUWAL, Bern 1991).

7. S. Ahbe, A. Braunschweig, and R. Müller-Wenk, *Methodik für Ökobilanzen auf der Basis ökologischer Optimierung* [Methods for Ecobalances Based on Ecological Optimization], Schriftenreihe Umwelt No. 133 (BUWAL, Bern 1990).

8. See B. Commoner, *The Closing Circle* (Alfred A. Knopf, New York 1971).

9. R.G. Hunt and W.E. Franklin, *Resource and Environmental Profile Analysis of Nine Beverage Container Alternatives* (US EPA, 1974).

10. Arthur D. Little, *Resource and Environmental Profile Analysis of Selected Disposable versus Reusable Diapers* (American Paper Institute, Washington, 1977).

11. S. Hume, "McDonalds," *Advertising Age* 29 (January 1991) p. 32.

12. See Projektgruppe Ökologisches Wirtschaften, *Produktlinienanalyse: Bedürfnisse, Produkte und ihre Folgen* [Product Line Analysis: Needs, Results and Their Consequences] (Köln, 1987); J.A. Fava, R. Denison, B. Jones, et al., *A Technical Framework for Life Cycle Assessments* (SETAC Foundation, Washington, 1991); R. Grießhammer, C.O. Gensch, and K. Kümmerer, *Produktlinienanalyse und Ökobilanzen* [Product Line Analysis and Ecobalances] (Bibliographisches Institut, Mannheim 1992).

13. R. Pfriem, "Ökobilanzen für Unternehmen" [Ecobalances for Firms] in R. Pfriem, ed., *Ökologische Unternehmenspolitik* [Ecological Organization Policy] (Campus Verlag, Frankfurt/New York 1986), pp. 210-226; R. Pfriem, *Ökologische Unternehmensführung* [Ecological Organizational Leadership], Schriftenreihe des IÖW No. 13 (Institut für Ökologische Wirtschaftsforschung, Berlin 1988); H. Hallay, ed., *Die Ökobilanz—ein betriebliches Informationssystem* [The Ecobalance: A Managerial Information System], Schriftenreihe des IÖW No. 27 (Institut für Ökologische Wirtschaftsforschung, Berlin 1989).

14. See B. Wagner, "Vom Öko-Audit zur betrieblichen Öko-Bilanz [From Eco-Audit to Whole-Firm Ecobalance], paper presented in Garmisch-Partenkirchen (November 1992); V. Stahlmann, *Umweltorientierte Materialwirtschaft: Das Optimierungskonzept für Ressourcen, Recycling, Rendite* [Environmentally-Oriented Production: The Optimization Concept for Resources, Recycling, and Profits] (Wiesbaden 1988); V. Stahlmann, "Ziel und Inhalt ökologischer Rechnungslegung—vom Teil zum Ganzen," [Goal and Content of Ecological Accounting: From Part to the Whole] in M. Beck, ed., *Ökobilanzierung im betrieblichen Management* [Ecobalances in Business Management] (Vogel Verlag, Würzburg 1993), pp. 91-145.

15. E. Günther and B. Wagner, "Ökologieorientierung des Controlling (Öko-Controlling)" [An Ecologically Oriented Controlling], *Die Betriebswirtschaft* 53 (1993) pp. 143-166.

16. Notable by its absence was the observation that McDonald's receives much of its food in a partially or wholly prepared form.

17. V. Stahlmann, *Umweltorientierte Materialwirtschaft: Das Optimierungskonzept für Ressourcen, Recycling, Rendite* [Environmentally Oriented Production: The Optimization Concept for Resources, Recycling, and Profits] (Wiesbaden 1988).

18. For an introduction to ABC methods, see K.L. Bartlett, R.R. Lester, and R.B. Pojasek, "Prioritizing P2 Opportunities with Activity-Based Costing," *Pollution Prevention Review*, Vol. 5, No. 4 (Autumn 1995).

19. Clausen, Hallay, and Strobel have developed a rather comprehensive system of environmental ratios for analysis. See M. Strobel, "Ein ökologieorientiertes Kennzahlensystem" [An Ecologically Oriented Ratio System], in J. Clausen, H. Hallay, and M. Strobel, eds., "Umweltkennzahlen für Unternehmen," [Environmental Ratios for Organizations], IÖW Discussion Paper No. 20 (1992) pp. 21-37. Additional examples may be found in H. Hallay and R. Pfriem, *Öko-Controlling: Umweltschutz in mittelständischen Unternehmen* [Eco-Controlling: Environmental Protection in Mid-Sized Firms] (Campus, Frankfurt/New York 1992).

20. Greenpeace, "Viel zu kostbar für die neue S-Klasse" [The S-Class Is Much Too Costly] (1990).

21. E. Günther, *Ökologieorientieres Controlling* [Ecologically Oriented Controlling] (Vahlen, Munich 1994) offers a careful exposition of the basic precepts and theory behind an ecologically oriented controlling system. W. Hopfenbeck and C. Jasch, *Öko-Controlling* [Eco-Controlling] (Moderne Industrie, Landsberg am Lech 1993) provides a thorough review of this topic and the ecobalance concept in general.

22. Numerous initiatives in environmental accounting, reporting, and performance measurement are under way across the world. See United Nations Environment Program, *Company Environmental Reporting: A Measure of the Progress of Business and Industry Toward Sustainable Development* (United Nations, New York, 1994); D. Ditz, J. Ranganathan, and R.D. Banks, eds., *Green Ledgers: Case Studies in Corporate Environmental Accounting* (World Resources Institute, Washington, 1995).

23. See the article by S. McLaughlin and H. Elwood, elsewhere in this issue, entitled "Environmental Accounting and EMSs."

24. R.A. Frosch and N.E. Gallopoulos, "Strategies for Manufacturing," *Scientific American* 261, pp. 144-152 (1989); T.E. Graedel and B. Allenby, *Industrial Ecology* (Prentice Hall, Englewood Cliffs, 1995).

Mark A. White is Assistant Professor of Commerce at the University of Virginia's McIntire School of Commerce. **Bernd Wagner** is a professor and member of the board at the Universität Augsburg's Kontaktstudium Management, a German executive training institute.