The "Ecobalance" as a Tool for Environmental Financial Management

White, Mark A.

Wagner, Bernd

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Abstract

High levels of environmental concern have provided the impetus for German firms to develop sophisticated systems for identifying, measuring and tracking environmental

performance. This article describes the development and use of a new instrument, the "ecobalance," to collect and organize environmental data for the purposes of pollution prevention, cost reductions and environmental financial management.

> "... when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind." William Thompson (Lord Kelvin)

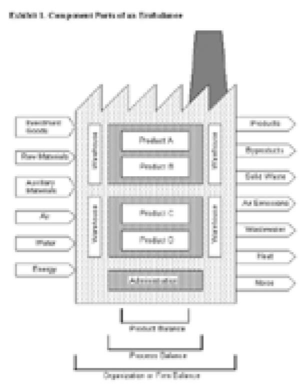
Environmental issues are a growing strategic concern for businesses in both the United States and Europe. Rising consumer sentiment, increasingly stringent governmental regulations and skyrocketing costs for pollution control and waste disposal are affecting the competitive position of firms on both 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 concept of environmental auditing and/or environmental reporting, ecobalances also incorporate aspects of product life cycle analysis. As such, they offer a useful method of evaluating environmental impacts for purposes of pollution prevention, bridging the gap between standard accounting practice (where data is expressed solely in monetary terms) and qualitative environmental reporting.

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 the United States, but its population density is much greater--almost ten times larger. 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 top concern (Schwarz, 1993). In the United States, the environment ranked third (tied with racism and unemployment), received 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 spent a larger percentage of their gross domestic product (GDP) on environmental protection than any other nation in the world (Husmann & Scherer, 1993).

This article discusses the use of the German "ecobalance" as a managerial tool for pollution prevention and environmental financial management. Specifically, preparation of an ecobalance assists a firm in: a) Identifying opportunities for pollution prevention and cost savings, b) Prioritizing these opportunities for later implementation, and c) Measuring the performance of pollution prevention efforts. Section One provides a brief historical review of the ecobalance approach and differentiates it from other instruments used for similar purposes. Section Two contains the details on how to go about actually conducting an analysis--obtaining resources, defining goals, collecting data and structuring the report. In Section Three, various methods for interpreting the results are discussed. The paper concludes with reflections on the future development of this tool and its usefulness to American firms.

What Is An Ecobalance and How Is It Used?

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.[1] It is similar to the "mass and energy balance" approach, in that data in an ecobalance is collected and reported in a multitude of physical units, e.g., pounds, gallons, square feet, kilowatt-hours, which increases flexibility and speeds implementation. 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 one 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 balances make up a firm's ***ecobalance*** .

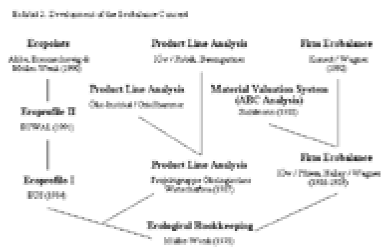
During the course of preparing its first ecobalance in 1991, Europe's largest manufacturer of nylon stockings, ***Kunert AG*** , discovered an enormous shortfall between annual water inputs and annual water outputs. An in-depth investigation revealed a leak deep beneath the firm's manufacturing plant which had existed for more than ten years![2] ***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. Cost reductions and protection of natural resources are a priority for ***Staatliche Mineralbrunnens Bad Brückenau*** , a major bottler of natural mineral waters in middle germany. By keeping better track of water and detergent use, the firm has reduced its materials and waste disposal costs and safeguarded its primary source of supply. These firms were among the first to pioneers of the ecobalance concept. Today, large 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. Often data expressed in physical units generates new insights. For instance, managers at a bank in southern Germany with 241 branches had sometimes wondered about the strange fluctuations in their bill for total energy use. While conducting an ecobalance analysis, data was collected on the total area (m^2) of each affiliate. Comparing these figures against the individual utility bills revealed large differences in the energy efficiency of the various subsidiaries.

History of the Ecobalance Concept

The early roots of ecobalance analysis can be traced to Müller-Wenk's (1978) concept of an "ecological accounting," based on the notion that products whose manufacture entailed higher environmental costs should carry higher prices. Envisioning that departments would eventually be held accountable for their environmental as well as their financial budgets, he developed a set of accounts measuring the environmental impacts of greatest concern at the time.

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 (Exhibit 2).



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 comparing the effects of competing packaging technologies with one another based on "critical thresholds" for environmental damage (BUS, 1984; BUWAL, 1991). 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 different technology under investigation. This system has since been refined, collapsing all of a product's environmental impacts into a single dimension, the so-called "eco-points" (Ahbe, Braunschweig and Müller-Wenk, 1990).

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 (cf. Commoner, 1971). Isolated studies were carried out in the following decade, e.g., Franklin Associates' work on beverage containers (Hunt and Franklin, 1974) and Arthur D. Little's (1977) study of disposable vs. cloth diapers, but research in this area decreased as public interest in environmental issues faded during the late 1970s and early 1980s. A renewed wave of environmental consciousness manifested itself in the late 1980s. Shoppers debated whether paper or plastic was the better choice at checkout counters while young parents anguished over the choice of cloth vs. disposable diapers.

Studies investigating the environmental impact of products over their entire life cycle--resource extraction, refining, manufacturing, transportation, use and disposal--came into vogue, accompanied by catchy descriptions, e.g. from the "cradle to the grave" or from "womb to tomb." However, their recommendations were not always heeded. In a highly-publicized decision, McDonald's stopped packaging its hamburgers in polystyrene "clamshells" and switched to a predominantly paper wrap, despite evidence that polystyrene packaging was actually less harmful to the environment (Hume, 1991). ***Product line analysis*** (PLA) and/or ***life cycle analysis*** (LCA) continue to flourish in both the United States and Europe (Projektgruppe Ökologische Wirtschaft, 1987; Fava et al., 1991; Grießhammer, Gensch and Kümmerer, 1992). Two US organizations, ***Green Seal*** and ***Scientific Certification Systems*** , issue environmental product labels based in part on these methods.

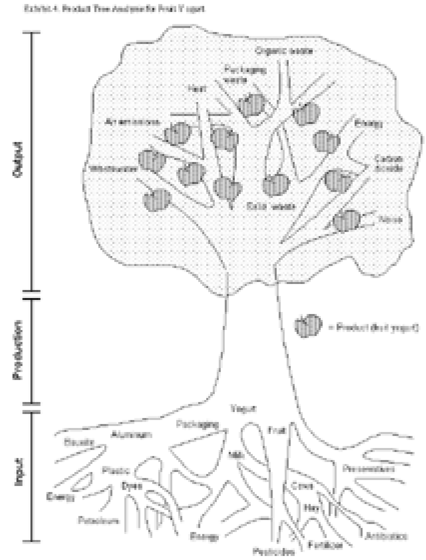
A more ambitious project designed to measure environmental impacts on a `whole-firm' basis was begun in the late 1980s at the ***Institut für Ökologische Wirtschaftsforschung*** (Institute for Environmental Economic Research, or IÖW) in Berlin. There, researchers developed an ecobalance concept consisting of three sub-balances (not necessarily nested within one another) combined with a life cycle analysis of all the firm's major products (Pfriem, 1986, 1988; Hallay, 1989). Over the past five years, a number of researchers have made alterations or adjustments to this basic model (Wagner, 1992; Stahlmann, 1988; 1993). ***Kunert AG*** was the first company to make its ecobalance analysis available to the general public.

Product Tree Analysis

A chief distinction between the ***Kunert*** ecobalance and other published reports is its abandonment of the product life cycle concept. Product life cycles are frequently represented as a straight line (Exhibit 3), although manufacturing processes are rarely linear.

Exhibit 3. Conventional Life Cycle Analysis

An alternative model, "product tree analysis," offers certain advantages in understanding a firm's input and output functions and is useful in reducing complexity. In this approach, the firm's production process is not viewed as a straight line, but rather as a tree. Exhibit 4 shows a simplified product tree for prepackaged fruit yogurt.

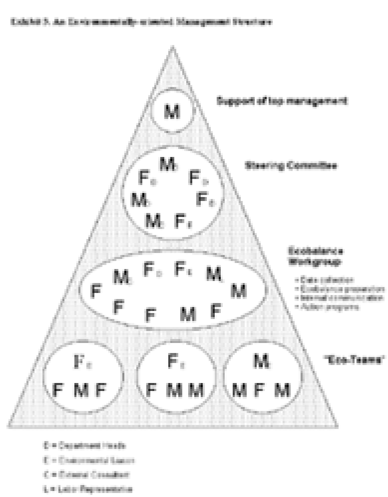


Initial inputs of land, energy and raw materials might be likened to a tree's tangled roots, weaving in and about each other while creating secondary materials for use in a variety of later products and processes. The actual production takes place in the tree's trunk. Multiple divisions are easily characterized by forked or split trunks. The tree's branches yield both desirable fruits (products and services) and undesirable remnants (air emissions, wastewater, waste heat, etc.). The decentralized and spreading nature of some firms bears more than a little resemblance to a tree's canopy. Perhaps the greatest strength of this metaphor is that it does not confine one to exploring ***all*** possible branches. Small boys (and girls!) know which branches are the most useful when climbing their favorite tree. Others receive little notice or are twisted off and dropped on passers-by. Managers are well aware which products and processes consume the greatest resources and contribute 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.

Implementing an Ecobalance Study

The Importance of Cooperation

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. An environmentally-concerned organization undertaking an ecobalance study of its activities might be structured as in Exhibit 5.



Support from the very highest levels of management is necessary for establishing the project's importance and in opening non-traditional lines of communication. A supervisory council composed of department heads, environmental specialists and generally an external consultant is responsible for overseeing the processes of data collection and analysis and deciding upon implementation programs based on the study's recommendations. It is also responsible for the coordination of information needs and for key decision variables, i.e. which product lines should be followed to their "roots" and which should receive more cursory treatment.

The ecobalance work group or "green team" is composed of representatives from all relevant functional areas--controlling, research and development, purchasing, production, marketing, finance, strategic planning, product design, quality control, health and safety, personnel, etc. 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 include:

- 1. Development of the overall concept, including construction of the various accounts, structuring the ecobalance sheet
- 2. Data collection (in cooperation with the respective functional areas)
- 3. Setting priorities and analyzing strengths and weaknesses in particular areas of interest, locating risks and saving potentials
- 4. Analysis of results and the development of measurable goals
- 5. Preparation of the final balance and commentary

The work group should strive at all times to maintain open communication between 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. Sometimes it will be necessary to contact external experts for assistance with technical data, e.g., waste disposal alternatives, pre-production processes, energy alternatives, etc. In these cases special project 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.

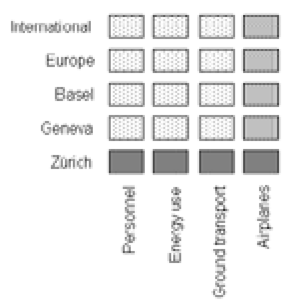
The entire project can be completed in six to twelve months, assuming the team meets every four to six weeks for a half-day or day. The study's costs include the work group's time, consultants' fees and miscellaneous administrative support costs. These are generally more than covered by the potential for energy and water savings, reduction of packaging, waste minimization and materials substitution (Günther and Wagner, 1993). 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 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*** . A first question 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, especial care should be taken to reduce misperceptions and miscommunications.

Second, the project must be manageable. Too large a scope places a heavy burden on often-scarce resources and may lead to a projecting collapsing under the weight of its own data. It is much better to start small and add departments, divisions etc. as experience is gained. Moreover, certain processes and products ("trunks" and "fruits" in product-tree-analysis vocabulary) carry a priority interest. Excluding less-critical areas saves resources and allows one to concentrate on more important spots. For instance, in its first report, Swissair chose to examine all environmental impacts arising from its activities at the Zürich airport, but restricted its efforts to airplanes alone with respect to its international operations (Exhibit 6).

Exhibit 6. Boundaries of the First Swissair Ecobalance



Differences of opinion exist with regard to what should be included in an ecobalance analysis. In the production of yogurt from cow's milk, for example, is it necessary to include fertilizer and pesticides used to grow hay for the cows? Should deaths from drunk driving or adverse health effects stemming from the use of alcohol be included in a brewery's ecobalance? In some respects, it depends on the intended audience and use of the resulting report. Thus, [3] As a managerial tool, good arguments can be mustered for stopping at doors of the organization, for this is where management exerts its strongest influence. However, it is also important to keep in mind the broader desires of society. mcdonalds 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 upon a high standard of rigor from the beginning. Assumptions and calculations should be clearly stated or 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

A first step is to set up the organization or firm accounts in cooperation with the supervisory council. An ***input-output scheme*** specifies the major areas of interest, e.g. air emissions, energy use, etc. An input-output balance sheet for the internationally-operating German machinery manufacturer ***Voith*** is shown in Exhibit 8.

Exhibit 8. Input-Output Balance for a Manufacturer

Input	91/92	92/93
1. Material (t)	66,951	50,107
1.1 Production material	29,954	19,296
1.2 Additional material	20,405	30,416
not differentiated	21,592	395
2. Investment (pieces)	1,678	591
2.1 Buildings	0	0
2.2 Technical equipment	1,609	551
2.3 Parking lots	69	40
3. Water (m3)	8,434,157	8,825,165
3.1 Drinking water	1,187,137	1,163,851
3.2 Production water	6,937,493	7,346,772
3.3 Rain water	309,527	314,542
4. Air		
4.1 Amount		
4.2 Pollution		
5. Energy (MWh)	304,938	291,788
5.1 Natural gas (Hu)	242,079	259,648
5.2 Heating oil (Hu)	39,210	9,937
5.3 Electricity	19,857	19,162
5.4 Fuel (Hu)	3,792	3,041

Output	91/92	92/93
1. Products (t)	38,068	39,863
1.1 Paper/material technology	18,046	19,609
1.2 Propeller technology	8,548	7,736
1.3 Electrical technology	5,670	5,874
1.4 Foundry	5,804	6,644
2. Refuse		
2.1 Investment waste (pieces)	238	700
2.2 Recoverables (t)	13,981	13,833
2.3 Waste (t)	28,501	1,101
2.4 Soil removal (t)		722
3. Wastewater (m3)		
3.2 Amount (m3)	8,434,157	8,825,165
3.2 Pollution		
4. Air emissions		
4.1 Amount		
4.2 Pollution		
5. Energy use (MWh)	304,938	291,788
5.1 Electricity	2,594	1,953
5.2 Steam	26,817	30,221
5.3 Remaining energy	275,527	259,614

Source: J. M. Voith Gmbh, der Umweltbericht 1992/93

In all probability, it will prove impossible to collect data for some of accounts, e.g., air inputs and noise. Their presence on the balance sheet serves as a useful reminder, however, of areas for improvement. The five major categories of inputs are: 1) Raw/auxiliary materials and non-capital goods, 2) Investment, i.e., capital goods, 3) Water, 4) Air and 5) Energy. Corresponding output accounts are: 1) Products, 2) Solid waste, 3) Wastewater, 4) Air emissions and 5) Energy losses (heat, noise). Specific details of the accounts will of course differ from firm to firm.

As the ecobalance method is still in its infancy, there are numerous variations on this basic theme. Exhibit 9 presents a general structure for treating the single accounts in an ecobalance statement.

Exhibit 9. 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
    - a) Absolute goals (zero emissions of substance z by time t)
    - b) Relative goals (x% decrease by time t)
  - Activities to Achieve Goals

Appendix-Derivation of Measurements

Cross-sectional comparisons of resource use and/or emission 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.

Analysis of Results

An ecobalance is a management tool, useful as an environmental rallying point and in improving the flow of information throughout the firm Once data has been gathered, several kinds of analysis may be performed. The first merely extends 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? After the green team's best efforts, there is still likely to be a shortfall between inputs and outputs. Identifying the cause of this shortfall can yield interesting results, as in the case of Kunert's missing water supply noted earlier.

Focusing on the biggest branches first can yield significant rewards. 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 its 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 its dye engineers were successful. The new dye contained no chromium, worked just as well, was cheaper, and removed the need to build the 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 have a new treatment plant.

Other methods of analysis include ABC analysis, environmental ratio analysis and environmental cost accounting or "eco-controlling." ABC analysis is a common technique in inventory control systems, but relatively new in environmental control systems (Stahlmann, 1988). It involves the prioritization of environmental problems in terms of their severity and/or ease of remediation. Firms then focus first on those pollution prevention opportunities with the greatest benefit-to-cost ratios, i.e., the "low-hanging fruit."

Environmental ratio analysis is akin to financial ratio analysis, taking values from the completed ecobalance and re-expressing them in a different form for better presentation of information. 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 (Greenpeace, 1990). This is a production efficiency of 2.2 tons/54.2 tons or about four percent. ***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 10).

Exhibit 10. 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	

Clausen, Hallay and Strobel (1992) have developed a rather comprehensive system of environmental ratios for analysis. Additional examples may be found in Hallay and Pfriem (1992).

Finally, research to develop environmental cost accounting and eco-controlling systems is in progress. The basic thrust is to expand the investment decision to include potentially hidden or contingent costs. 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. The US Environmental Protection Agency currently has a large program underway to more fully identify and account for these kinds of costs (USEPA, 1995). In

Germany, Günther (1994) offers a careful exposition of the basic precepts and theory behind an ecologically-oriented controlling system, while Hopfenbeck and Jasch's (1993) text provides a thorough review of this topic and the ecobalance concept in general. Numerous initiatives in environmental accounting, reporting, and performance measurement are underway across the world (UNEP, 1994; Ditz, Ranganathan and Banks, 1995).

Conclusion

Preparation of an ecobalance and its subsequent analysis provides numerous benefits, particularly with respect to implementing and measuring programs for pollution prevention. First, the results allow a firm to identify environmental weak points, e.g., areas with high emissions, processes generating unusually large amounts waste, etc. This knowledge provides information for developing environmental strategies and/or reducing costs. In the early 1970s, for instance, ***Henkel*** , then Germany's largest manufacturer of phosphate detergents, recognized its products' role in the eutrophication of fresh waters, and 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 exercise itself is valuable as a method of fostering cross-departmental communication and providing a purpose for environmental dialogue. It can be used as a focus point for increasing awareness of environmental issues throughout the corporation, for example. This is particularly important if management wishes to effect change. Before any significant transformation can occur, employees must internalize the <="" i=""> for change. Participation in the gathering and analysis of ecobalance data can facilitate this commitment.

The ecobalance approach may also serve as the 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 Organization is currently at work on ISO 14000, a set of environmental management guidelines similar to the well-known ISO 9000 quality standards. Firms are expected to adopt these standards for market and competitive reasons, to gain favorable regulatory treatment, improve their public image and as a means of achieving environmental excellence (Freeman and Belcamino, 1995).

A final possible application for ecobalance analysis is in the fledgling discipline of industrial ecology (Frosch and Gallopoulos, 1989; Graedel and Allenby, 1995). 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. In Kalundborg, Denmark, waste steam from a coal-fired electricity plant is used in the production of pharmaceuticals, excess heat is channeled to a nearby town and to warm the company's fish farm, and 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.

By emphasizing inputs and outputs, ecobalances confront pollution problems head-on. ***Preventing*** pollution at the beginning of the pipe is in many cases the wisest course of action, as it simultaneously decreases resource use and avoids costly waste treatment or disposal. As a managerial tool, ecobalance analysis provides the means for early identification of 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]Unfortunately, there is currently a great deal of confusion regardingterminology in this area. The term "ecobalance" is also used for comparative analyses of materials, products and technologies, although not hing really ***balances*** in these studies. See Rubik and Baumgartner (1992) for further discussion of this issue.

[2]The company was essentially paying ***twice*** for water it wasn't able to use. . . first as incoming (scarce) drinking water and again as outgoing wastewater (because the latter's cost was ca lculated using input figures).

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

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Notes

[1]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. See Rubik and Baumgartner (1992) for further discussion of this issue.

[2]The company was essentially paying twice for water it wasn't able to use ... first as incoming (scarce) drinking water and again as outgoing wastewater (because the latter's cost was calculated using input figures).