EcoMetrics: Integrating Direct and Indirect Environmental Costs and Benefits into Management Information Systems

Gil Friend

This article suggests a set of metrics that may impact both profitability and environmental quality, capture and quantify eco-efficiency costs and benefits, and help managers understand and focus on tangible, yet difficult-to-quantify benefits (such as improved morale, innovation, etc.). In order to do this, it will frame the issues pertinent to developing eco-efficiency metrics; identify criteria for effective metrics to enable companies/consultants/etc. to discuss, evaluate, and select program metrics; outline the universe of possible metrics; suggest key metrics for a typical company; identify data quality, availability and other constraints; and suggest a methodology for incorporating environmental metrics into operating metrics.

[Note: This article is not intended to provide a definitive overview of environmental metrics; rather, it proposes an operational framework for considering, selecting, and implementing metrics that are meaningful in both environmental and business terms. For an overview, see for example, Environmental Policy Performance Indicators;[1] Company Environmental Reporting;[2] The Greening of Industrial Ecosystems;[3] Measuring Corporate Environmental Performance.[4]]

> The flow and embodiment of materials and energy in production and consumption activities of the economy underlie both economic growth and environmental perturbations. . . . [Yet] existing accounting systems can prevent modern firms from internalizing environmental costs and considerations, and can compound difficulties encountered in effecting environmentally preferable changes.[5]

Any company, whether in regulated or competitive mode, must demonstrate efficient use of its capital and intellectual resources. Profit, after all, is a cost of doing business. But resources are a cost of doing business too. It makes little sense to purchase more resources than you need, and even less sense to produce a product that you don't sell—which, after all, is what pollution is. Since "what gets measured gets managed," it is essential that companies select appropriate metrics for program evaluation and management.

Integration of environmental performance indicators (EPIs) with business indicators is still relatively rare, especially among small- and medium-sized enterprises (SMEs). This is not surprising, since integration of EH&S with business issues in general is still more the exception than the rule, and since SMEs generally tend to be less sophisticated about metrics than larger firms.

All too often, corporate environmental metrics track exogenous factors like emissions, or otherwise business-irrelevant factors like EH&S expenditures. But does it really help the environment or corporate performance to increase spending on EH&S? Shouldn't the key be results per unit expenditure, as with any traditional business measure?

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In our experience, recycling and recycled content are probably the most commonly tracked nonregulatory environmental metrics among SMEs, with energy use (as a gross quantity) in second place. However, metrics that place data in a meaningful context (e.g., trendlines, normalized data, etc.) seem to be quite rare.

Because environmental and economic domains interact, it is essential to extend metrics beyond direct energy efficiency and financial return to include an *integrated assessment* of environmental costs and benefits, and their impacts on customer profitability, or "eco-efficiency."

Companies need a method to account for a broad range of environmental costs and benefits—some of which lend themselves more readily to evaluation in monetary terms. The accounting and evaluation methodologies are dealt with in other documents; this article focuses on identifying an expanded universe of environmental metrics on which those methodologies can draw.

The emerging discipline of "industrial ecology" provides an organizing framework for eco-efficiency metrics.

The emerging discipline of "industrial ecology" provides an organizing framework for eco-efficiency metrics. "Industrial metabolism"—that is, quantification and analysis of the input and output flows of energy and cycles of materials through the system under review, whether it is a facility, a company, an industry or a region—offers a framework that can be used to identify and select relevant metrics. These can in turn be used to assess both financial and resource productivity, including environmental improvement, productivity gains, product quality improvement, enhancement of corporate image with customers, etc.

PURPOSE OF ECO-EFFICIENCY METRICS

Eco-efficiency metrics must serve two distinct yet interrelated purposes:

- *Performance Evaluation.* They must enable a company to consistently evaluate program effectiveness, and optimize its design and delivery, in relation to both the impact of the program, in terms of its energy, environmental, and economic benefits, and the efficiency of program delivery, in terms of cost-effectiveness and quality of implementation.
- *A Management Feedback Tool.* They must provide useful management feedback, to encourage, assist and reward implementation— especially in light of historic barriers to implementation of energy efficiency opportunities. Managers may be interested in a purely financial assessment of eco-efficiency strategies, or may also wish to track resource productivity in its own terms, as an element of corporate sustainability strategies.

Key Goals

Cost-Effective Results

From a corporate or financial manager's perspective, cost-effective results mean meeting resource and waste reduction goals per dollar invested. From an operating manager's perspective, cost-effective resource efficiency results mean meeting financial payback goals. From an eco-efficiency perspective, cost-effective resource efficiency results mean profitably reducing resource throughput and current or potential environmental burdens.

Financial Returns

Return on investment (ROI) remains the central financial metric. Eco-efficiency metrics add additional elements, and may reflect a life cycle costing perspective, to incorporate other potential benefits into financial decision making.

Because "whole systems accounting" or "full cost accounting"—integrating the economic consequences of "externalities" into management decisions—is a field that is still evolving, it can be challenging to meaningfully compare metrics that may be of a very different nature such as energy efficiency and toxic emissions. For that reason the Dutch National Environmental Policy Plan (NEPP), for example, tracks distinct classes of metrics, aggregating metrics as much as possible within classes, but not between them.

A growing body of practice in monetizing environmental costs and benefits—ranging from Tellus Institute analysis of the "true cost" of packaging materials to the California Public Utility Commission's Integrated Resource Planning (IRP) procedure and tradable pollution rights—suggests ways to broaden the range of costs and benefits caught in the financial net.

Environmental Efficiency

Assessing environmental quality requires that many disparate factors be evaluated; direct comparisons among these factors must be made carefully to ensure that the comparisons are meaningful.

Environmental factors that could be taken into account include: energy and resource use (both direct costs and benefits) such as demand side management (DSM) investments and reduced energy bills, and avoided costs (such as reduced waste processing and resource procurement costs); production efficiencies (such as reductions in production costs); environmental burdens (such as toxic emissions); and regulatory compliance (costs of compliance and noncompliance) resulting from eco-efficiency initiatives. When possible, these should be evaluated on a "life cycle" basis, and those aggregated costs factored into ROI and payback calculations.

The greatest management leverage may be gained in identifying opportunities to integrate environmental and financial benefits, for example:

- Reduce cost/unit of production;
- Reduce the quantity of environmental pollutants released;
- Reduce environmental risk;
- Improve workplace conditions;
- Expand production with the existing physical plant;
- Enhance product quality;
- Enhance corporate image; and
- Increase sales.

Productivity

Industrial management generally has emphasized labor and capital productivity over resource productivity. While labor is typically a significantly larger portion of production costs than natural resources, resource costs are far more malleable; moreover, gains in resource productivity can contribute to the other two, while being a direct pathway to reduced environmental impact. Well-chosen metrics should support companies in designing such three-way productivity gains, rather than trading one off against another.

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As Herman Daly observed:

> Historically, technological progress has favored capital and labor productivity at the expense of resource productivity (e.g, declining energy producitivity in agriculture resulting from greater use of energy per unit of labor and capital, with consequent increases in labor and capital productivities). Sustainable development implies a different direction of technical progress, one that squeezes more service per unit of resource, rather than one that just runs more resources through the system—one that is efficiency-increasing rather than throughput-increasing—one that does not sacrifice natural resource productivity and, if necessary, will sacrifice labor or capital productivity instead.[6]

Daly posits a zero sum game among these three. But is it not possible to increase productivity of all three, synergistcally?

Customer Perception

Since building market share is a key business goal, the impact of resource efficiency programs on customer loyalty should be considered as an additional "success metric," as well as other indirect benefits that may result from eco-efficiency programs (e.g., improvements in product quality, employee morale and technical innovation) certainly tangible if not obvious benefits.

In addition, marketplace benefits may result from "greening" of its operations and/or products. While there has been limited work to quantify this linkage or its implications, Church & Dwight determined that environmental initiatives return 2.5 times the return of traditional advertising.[7]

Criteria for effective metrics

According to *Company Environmental Reporting*,[8] a recent survey by the United Nations Environment Program (UNEP), the usefulness of effective environmental metrics depends on six key factors:

When a large universe of metrics is indicated, it will be important to nest them hierarchically to minimize information overload.

- Comparability;
- Scope;
- Credibility;
- Quantification;
- Transparency; and
- Extendibility.

Albert Adriaanse, discussing the Dutch NEPP, lists six requirements for indicators:

- Select a limited number, as aggregative as possible;
- Must have definite appeal, be aptly presented;
- Reflect a trend, with appropriate time scale;
- Relate to cause and effect;
- Relate actual developments, in time, to objectives and actions; and
- Be verifiable and reproducible.

and five "key points" for development of indicators:

- Quality aspects;
- Sensitivity in time;
- Policy relevance;
- Recognizability; and
- Clarity.

In practical terms, the governing criteria for selecting effective metrics are:

- Data are available and accurate;
- Metrics are meaningful; and
- Metrics are "actionable."

In addition, while there are many factors that may be relevant to measure (in that they are meaningful reflections of efficiency), metrics ultimately selected for program evaluation and management should be relatively few in number, or managers and workers can be lost in a flurry of data. When a large universe of metrics is indicated, it will be important to nest them hierarchically to minimize information overload.

From an operational perspective, well-chosen EMS metrics should enable employees as well as managers to (in a paraphrase of J.M. Juran):

- Identify what goals they want to achieve;
- Integrate those goals into their operations; and
- Evaluate their progress toward those goals.

This bears an obvious relationship to Total Quality Management (TQM) principles, and will allow customers to integrate eco-efficiency initiatives with TQM programs.

UNIVERSE OF POSSIBLE ECO-EFFICIENCY METRICS

Types of Measures

Any metric, environmental or other, can be most meaningfully used when presented in relationship to something else: another metric or production factor, a change over time, a rate of change, comparable factors within the industry (benchmarking), etc. (see **Exhibit 1**). The

Exhibit 1. EcoMetrics™: Eco-Efficiency Performance Indicators

	Measure	Units	Assess In Relation To	Monetized Value (Expended or Avoided)	Energy Implications	Tier	Data Source
Cost structure	Energy	$, %	Expenditures, Value added	Cost to procure			CAS (Customer Accounting System)
	Water	$, %	Expenditures, Value added	Cost to procure			CAS
	Materials	$, %	Expenditures, Value added	Cost to procure			CAS
	Labor	$, %	Expenditures, Value added	Cost to procure			CAS
Inputs							CAS
Materials Consumption	Total	Types, classes	Per Product Unit (PPU) Revenue	Cost to procure, ship, store	Embodied (e.g., manufacture, transport)	1	CAS
	Renewable	Tons, %	Total materials(TM)	Cost to procure, ship, store	Embodied	2	CAS
	Non-Renewable	Tons, %	TM	Cost to procure, ship, store	Embodied	2	CAS
	Toxic materials	Tons, %	TM, PPU	Cost to procure, ship, store	Embodied	2	CAS
	Hazardous materials	Tons, %	TM, PPU	Cost to procure, ship, store	Embodied	2	CAS
	Secondary content	Tons, %	Total Materials	Cost to procure, ship, store	Embodied	2	CAS
	High value materials	Tons, %	Total Materials	Cost to procure, ship, store	Embodied	2	CAS
	Large quantity materials	Tons, %	Total Materials	Cost to procure, ship, store	Embodied	2	CAS
	Vulnerable supply materials	Tons, %	Total Materials	Cost to procure, ship, store	Embodied	2	CAS
	Materials cost	$, %	Production cost ($) Revenue	Cost to procure, ship, store	Embodied	1	CAS
Energy Consumption	Consumption (Utilities, electricity, gas)	kWh, therms $	PPU, per dollar revenue	Cost to procure		1	Utility bills, records
	Demand (Utilities: electricity)	kW	PPU, per dollar revenue	Cost to procure		1	Utility bills, records
	Other energy inputs (e.g., fuels, steam, biofuels)	Btu, bbls of oil, gallons, $	PPU, per dollar revenue, total energy use	Cost to procure		1	Production records, metering
	Waste heat—lost		PPU, %	Cost to procure		2	Calculated
	Waste heat—recaptured		PPU, %	Cost to procure		2	Calculated
	Energy cost (Total)	$, %	Production cost ($), revenue, PPU	Cost to procure		1	Utility bills, records; CAS
Water Consumption	Total gallons	gallons	PPU	Cost to procure	Embodied, pumping, heating, conditioning, processing	1	Utility bills, records
	consumption, fresh	gallons	PPU	Cost to procure	-	2	Utility bills, customer records
	consumption, reclaimed	gallons	PPU	Cost to procure	-	2	Utility bills, customer records
	Various uses	gallons	PPU	Cost to procure	-	3	Customer production records
	Water cost	$, %	Production cost ($), revenue, PPU	Cost to procure	-	1	Utility bills, records; Customer accounting system
Labor	Labor	Headcount, person-hours	PPU, per dollar revenue	Payroll (fully loaded)	Commuting	1	Customer
Outputs							
Solid Waste	Total waste generated (NPO="non-product output")	(by category) Tons	Production, Revenue	Disposal, treatment, insurance, contingent liability	Treatment, transport, disposal	1	Manifests, logs, mandated reports, mass balance
	Municipal solid waste generated	Tons % (of total solid waste)	Production, Revenue, Total waste	Disposal, treatment, insurance, contingent liability	-	2	Manifests, logs, mandated reports, mass balance
	HazWaste generated	Tons, %	Production, Revenue, Total waste	Disposal, treatment, insurance, contingent liability	-	2	Manifests, logs, mandated reports, mass balance
	Toxic Waste generated	Tons, %	Production, Revenue, Total waste	Disposal, treatment, insurance, contingent liability	-	2	Manifests, logs, mandated reports, mass balance
	Waste Landfilled	Tons, %	Production, Revenue, Total waste	Disposal, treatment, insurance, contingent liability	-	2	Manifests, logs, mandated reports, mass balance
	TRI reportable	Tons, %	Production, Revenue, Total waste	Disposal, treatment, insurance, contingent liability	-	1	TRI reports
	Off-site disposal liabilities	$	Production, Revenue, Total waste	Insurance, contingent liability	-	3	CAS (?)
	Raw material to product conversion efficiencies	%	Procurement, Production		-	2	Customer records, calculated
	% of throughput lost to "waste"	%	Production, Revenue, Total waste	Cost to procure	-	2	Customer records, calculated
	NPO reused onsite	Tons, %	Production, Revenue, Total waste	Processing costs Treatment costs avoided Procurement costs avoided	-	3	Customer records, calculated
	NPO recycled, waste exchanged, sold, etc.	Tons, %	Production, Revenue, Total waste	Processing costs Treatment costs avoided Procurement costs avoided	-	3	Customer records, calculated
	Waste management cost (Total)	$, %	Production cost ($) Revenue	Disposal, treatment, insurance, contingent liability, revenue received	-	1	CAS
Air Emissions	Total emissions	Tons	Production, Revenue	Tradable Rights market value, treatment, insurance, liability	Treatment	1	TRI, other reports; mass balance
	greenhouse gasses*	Tons, %	Production, Revenue, Total emissions	Tradable Rights market value, treatment, insurance, liability	-	3	TRI, other reports; mass balance
	ozone depleting substances*	Tons, %	Production, Revenue, Total emissions	Market value, treatment, insurance, liability	-	3	TRI other reports; mass balance
	CO_2 emissions	Tons, %	Production, Revenue, Total emissions	Tradable Rights market value, treatment, insurance, liability [offset]	-	3	TRI other reports; mass balance
	TRI reportable	Tons, %	Production, Revenue, Total emissions	Tradable Rights market value, treatment, insurance, liability	-	1	TRI reports
	Indoor Air Quality —VOCs, particulate, other	Tons, %	Production, Revenue, Total emissions	Treatment, insurance, liability	-	3	On-site testing
	% of throughput lost to atmosphere	%	Production	Cost to procure		2	TRI reports, calculations
	Waste management cost	$, %	Production cost ($) Revenue	Treatment, insurance, contingent liability		1	CAS
Effluents	Total effluent	Gallons (or M-cuft)	Production, Revenue	Cost to process	Treatment	1	Utility bills, customer records
	Effluent (POTW?)	Gallons, %	Production, Total Effluent	Cost to process	-	2	Utility bills, customer records
	Onsite treatment	Gallons, %	Production, Total Effluent	Cost to process	-	2	Utility bills, customer records
	Effluent reclaimed for onsite use	Gallons, %	Production, Total Effluent	Cost to process Avoided cost to procure	Treatment; Avoided energy costs (pumping, heating, etc.)	2	Utility bills, customer records
	Effluent recycled	Gallons, %	Production, Total Effluent	Cost to process Avoided cost to procure	Treatment; Avoided energy costs (pumping, heating, etc.)	2	Utility bills, customer records
	TRI reportable	Gallons, %	Production, Revenue	Cost to process	Treatment	1	TRI reports
	Tons/M-cuft per material per year	Tons, %	Production, Revenue	Cost to process	-	2	Analysis, records
	BOD/COD	Tons, %	Production Revenue	Cost to process	-	3	Analysis, records
	% of throughput lost to water	%	Production	Cost to procure		2	Calculated
	Waste management cost	$, %	Production cost ($) Revenue	Treatment, insurance, contingent liability		1	Utility bills, customer records
Packaging	Tons/year by type	Tons	Production, Revenue	Cost to procure		1	Customer records, calculated
	Weight of packaging per weight (or unit) of product	Pounds, %	Production	Cost to procure	Embodied, transport, disposal -	1	Customer records, calculated
	% of output recycled	%	-			2	Customer records, calculated
	% secondary materials in product	%	-		-	2	Customer records, calculated
	%Recycled content	%	-	Cost to procure	-	2	Customer records, calculated
	% Post-consumer recycled content	%	-	Cost to procure	-	2	Customer records, calculated
	Quantities purchased (e.g., per month)	Tons, $	Production cost ($), revenue, PPU	Cost to procure	-	3	Customer records, calculated
	Quantities purchased shipped	Tons, $	-	Cost to procure	-	3	Customer records, calculated
	Quantities purchased disposed	Tons, $	-	Cost to procure	-	3	Customer records, calculated
	Cost						Customer records, calculated
	purchase cost	$, %	Production cost ($), revenue, PPU	Cost to procure	-	1	CAS

	Measure	Units	Assess in Relation To	Monetized Value (Expended or Avoided)	Energy Implications	Tier	Data Source
	disposal cost	$, %	Production cost ($), revenue, PPU	Cost to dispose (transport, landfill fees, etc.)	*	1	CAS
Throughput							
	Material & energy inputs/outputs per product unit	Pounds, kWh, $, %	Production cost ($), revenue, PPU	Cost to procure	Embodied, end use	1	Customer records, calculated
	% of output recyclable, % recycled	%		Cost to procure, dispose—avoided	*		Customer records, calculated
	% secondary materials in product	%	PPU	Cost to procure, dispose—avoided	*		Customer records, calculated
	Raw material to product conversion efficiencies	%	Procurement, Production		*		Customer records, calculated
	% of throughput lost to "waste"	%	Production, Revenue, Total waste	Cost to procure			Customer records, calculated
	% of throughput lost to atmosphere	%	Production, Revenue	Cost to procure			TRI reports, calculations
	% of throughput lost to water	%	Production	Cost to procure			Customer records, calculated
Other							
	Productivity	Units, Revenue	Labor hours, costs, time	Revenue/cost		1	CAS, calculated
	Absenteeism	Person-Days, %	Person-days	Replacement labor, training, defects		2	CAS, calculated
	Quality	Defects	Product units	Wasted product & materials, lost sales, cost of rework	Eliminating rework	2	CAS, calculated
	Insurance	$	Revenue, Product units	Cost to procure		2	CAS, calculated
	Booked toxic waste liabilities	$	Revenue, Product units	Impact on net worth		2	CAS, calculated
Denominators							
	Inputs	tons, sqft, units, $		Cost to procure		1	Customer accounting system
	Outputs	tons, sqft, units, $		Cost to process or dispose		1	Customer accounting system
	Time period	year, month, day		n/a		1	n/a
	Plant size	(1000) sq ft		n/a		1	Customer
	Labor force	#, person-hours		Payroll		1	Customer

Notes:

Data

Tier	*Collect this data*
1	Always
2	Often/Usually
3	Sometimes

*(NPO defined as any material output of any company process that does not become —or contribute to—a revenue generating product)

*Greenhouse gases

Primary: (98% of effect): CO_2, CH^4, NOX (NO^2), CFCs (CFC-11, 12,113, 114, 115), Halons (H-1211, H1301)

Secondary: CO, HC-100, HC-140a, HFC, HCFC

*Ozone depleting substances: CFCs (CFC-11, 12, 113, 114, 115), Halons (H-1211, H-1301)

*Acid rain contributors: SO_2, NOX (NO+NO^2), NH_3

*TRI: Toxic Release Inventory

–348 substances, as defined by Toxic Chemicals Subject to Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 [42 USCA §11023]

most meaningful denominators will vary by industry, management level, or personal preference. For that reason, software that is used to compile and analyze operating metrics should make it convenient to exchange denominators in a "what-if" exercise, perhaps in collaboration with the customer.

"Raw" data—quantities of individual resource flows—is of limited utility because it provides little guidance for effective action. For "data" to become "information" requires context. This can be done through trends, ratios, and benchmarks.

- *Ratios*. Put data in context—in relation to other flows and processes.
- *Trends*. Put data in context—in relation to time.
- *Benchmarks*. Put data in context—internally, in relation to customers' historic performance, and externally, in relation to competitors' performance.

Conversion Efficiencies

Taichi Ohno, architect of the Toyota Production System, noted in 1978: "Unless all sources of waste are detected and crushed, success will always be just a dream" (cited by Romm[9]). He was referring to waste of capital and labor, but the same logic extends to resource efficiency. As Bruce Cranford of the DOE observed more recently, "Companies that pollute are actually manufacturing 'products' that they're getting no revenue for."

Robert Ayres[10] has estimated that more than 90 percent of material "throughput" in the U.S. economy represents "waste," or "non-product output," in Bruce Cranford's telling phrase. If accurate, it suggests that a 10 percent improvement in conversion efficiencies would nearly double the economic yield of product from a given physical resource base. That makes conversion efficiency a particularly compelling metric for tracking resource productivity, and communicating it to the customer.

Examples could include:

- Raw material to product;
- Energy to product; and
- These can be crafted as "physical unit of input per financial unit of output" or "per physical unit of output."

Note that conversion efficiencies will vary widely from industry to industry; benchmarking comparisons are probably best limited to companies within a common industry.

Other Metrics

There is a growing body of evidence noting often unanticipated improvements as an ancillary result of eco-efficiency improvements—for example, increased worker productivity, reduced absenteeism, and improved product quality.[11] While it may prove difficult to isolate cause and effect to directly correlate these benefits to eco-efficiency improvements, they should be tracked as well.

It also may be worthwhile to monitor the rate of change of any metric, as well as to be attentive for industry-specific "key indicators" that may emerge in conversation with employees, vendors, and distributors.

SAMPLE KEY OPERATING METRICS

As noted above, selection of the most appropriate specific metrics from this large universe is dependent on factors unique to a customer's industry, and may be guided by management preference as well. So we offer these recommendations, including one or more metrics for each major resource "system," as a starting point for discussion rather than a definitive list.

Additional metrics may be relevant, based on scope of intervention with specific customers.

Energy
kWh/$ revenue
kWh/units of product
kWh/square foot

Water
Gal water/$ revenue
Gal water/unit of product
Gal water/square foot of facility

Conversion Efficiency
Tons of product/tons of inputs
Packaging input/unit of product

Non-Product Outputs
TRI releases/$ revenue
TRI releases/unit of product
Effluent / unit of product
Air emissions (CO_2,SO_2,NOX) / unit of product
Solid waste / unit of product
Hazardous waste / unit of product

Financial
Resource acquisition costs / revenue
Waste management costs / revenue
Operating margin
"Whole System Accounting" ROI

Procurement
Tons secondary / tons virgin
% recycled (by weight)
% recyclable (by weight)

Product
% recycled (by weight)
% recyclable (by weight)

Productivity
Production per unit of time
Materials and energy use per unit of product
Labor cost per revenue dollar
Changes in defect rates

Renewables
% of renewable energy
% of onsite renewables

USING ECO-EFFICIENCY METRICS

Each metric should be charted against time, in three ways:

- used within the enterprise;
- benchmarked against industry averages; and
- benchmarked against comparable companies.

Monetized values can be incorporated into the computation of ROI and project payback. Non-monetized values (those deemed relevant to the customer's industry) can be evaluated in relation to internal and external benchmarking. Both can be incorporated in a structured comparison of "base case" and "proposed alternatives." Rather than attempt to "force" monetized values on all metrics, a dual presentation can allow managers to add subjective valuation of environmental factors to objective evaluation of financial/environmental factors.

Full cost accounting may provide a useful framework for bridging any possible gap between corporate and facility perception of the payback of proposed eco-efficiency initiatives. For example, incentive contributions could be scaled to bring economic returns to desired payback levels, on the condition that payback calculations include full cost accounting.

Graphics

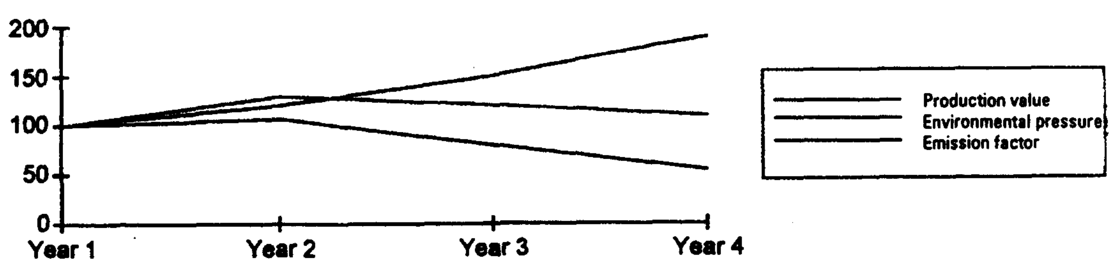
Metrics should be represented graphically wherever possible, to allow the widest recognition and understanding of eco-efficiency progress. Graphics should always show the relation of data—to time, in the form of trend lines, or to other data, in the form of benchmarks.

This charting scheme (**Exhibit 2**), used by the Dutch NEPP, provides a convenient and easy to grasp summary of trends in both environmental quality and economic productivity—in both absolute and relative terms—and is useful as a model for reporting environmental performance metrics.

An alternate approach forms part of GFA's Integrated EcoAudit process. Our Business Metabolics™ software maps resource throughput at the appropriate scale of interest (process, plant, company, region). Particular attention is paid to industrial metabolism and regional metabolism as key "reality based" metrics of environmental performance. The user interface allows users to select and compare performance ratios and trends that they find meaningful, and it encourages them to confront what we call the central business proposition: "More Value. Less Stuff." ("Stuff" is an intentionally blunt catchphrase for resource throughput of all kinds. Extraction, refining, processing, transformation, transportation, and use all have inevitable environmental consequences; the laws of thermodynamics make it clear that it simply cannot be otherwise. So strategies ranging from pollution prevention to dematerialization, which reduce the flow of "stuff" required per unit of added human value, offer essential leverage for meeting human needs in an environmentally sustainable way.)

In addition to the interactive overview main screen (**Exhibit 3**), Business Metabolics™ offers the client a small selection of "key indicators"—fewer than five if

Exhibit 2. Indicator Summary: Sample



Production value (PV) refers to revenue. Environmental pressure (EP) refers to resource use, emissions, etc. Emission factor (EF) is the ratio of EP+PV. Rising PV and falling EP and EF are the goals —and it is easy to see if they are being met.

Source: Dr. Albert Adriaanse, *Environmental Policy Performance Indicators* (see note 1).

Exhibit 3. Business Metabolics™ Overview Screen

possible, never more than eight—that summarize or represent the larger universe of relevant variables. Metrics are simply measures of data; indicators should "indicate"—indicate the import of larger data sets, and even indicate strategic directions.

The sample EQE Report shown in **Exhibit 4** demonstrates how a small set of key indicators can provide an integral control panel, accessible and understandable from the production line to the executive suite.

It is important to take care, when graphing eco-efficiency metrics, to orient metrics so that "good" and "bad" trends point in consistent directions. Some of the ratios that we have suggested release environmental pressure, rather than add to it, and may need to be inverted for the sake of consistency of presentation. Since most traditional business metrics are oriented as "up is good, down is bad," we prefer to orient environmental metrics in the same direction, so that anyone can read the EQE Report at a glance, even from across a plant floor.

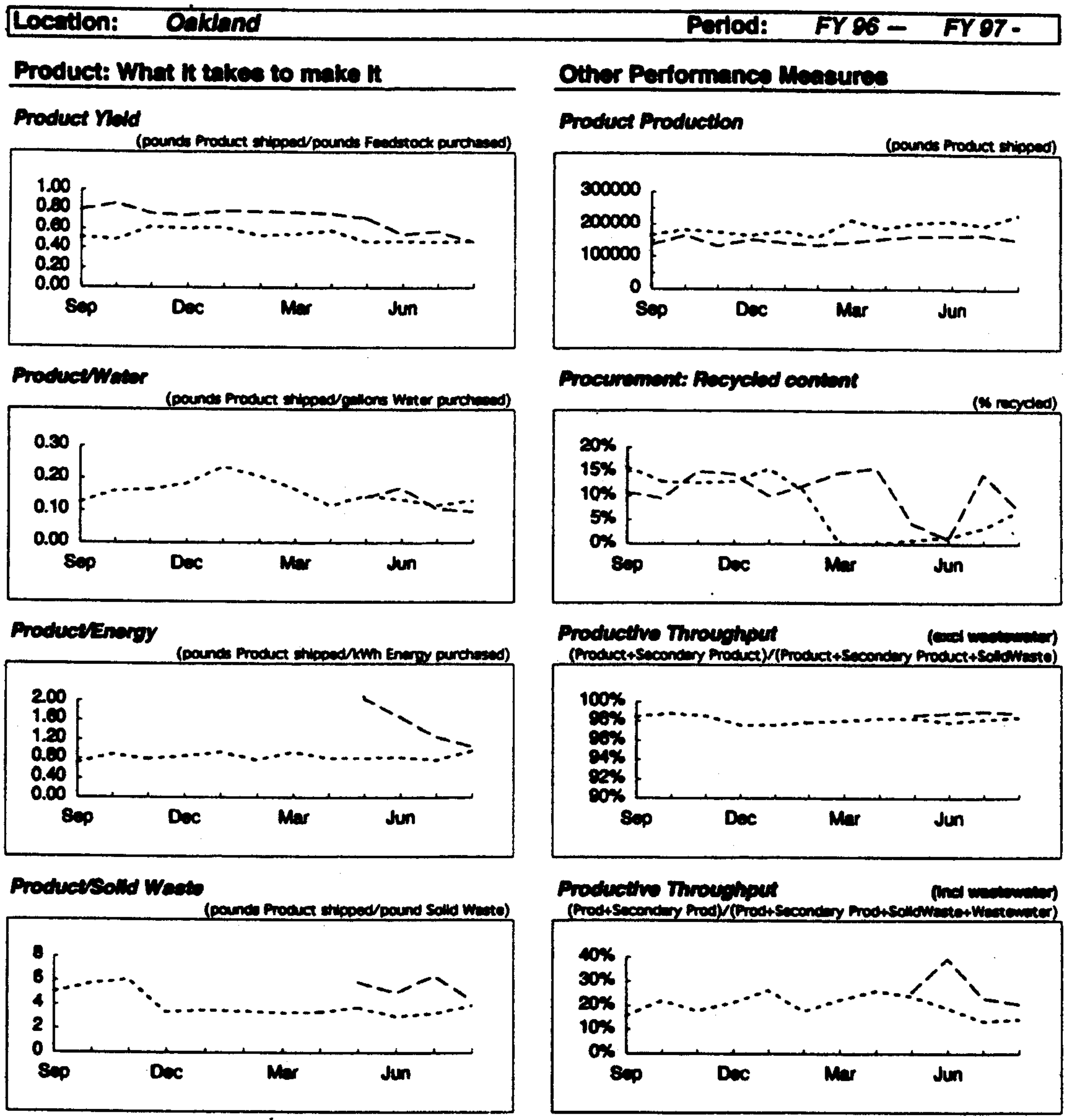
Constraints

Data Availability and Data Quality

Data availability and data quality can be significant constraints in constructing a sound environmental performance metrics system. Energy-use data are commonly among the most readily available, most likely to be both electronically readable and accurate. The same should be true for water and sewer data, if arrangements for machine-readable data can be made with water and sewer utilities. These data can be readily poured into spreadsheet templates or other software for analysis and reporting.

Other data may need to be extrapolated from company records. Typically, financial data will be available in machine-readable format, as direct output from a customer's accounting system, but often without many of the relevant distinctions noted

Exhibit 4. Company X EQE Report



Notes: This sample report from the author's Business Metabolics™ software provides an "at-a-glance" comparison of key trends in Environmental Quality and Efficiency (EQE) at one Company X location. Similar reports could be generated for other resources, and for company-wide data.

above. Data reflecting physical quantities, as well as re-aggregation of accounting system data, may have to be compiled by hand from invoices, shipping records, transportation manifests, etc. TRI data may or may not be available in machine-readable form, probably depending on customer scale and sophistication.

Manually-compiled data and financial data need to be converted to desired physical units, and then manipulated into desired indicators, ratios, and graphic presentations thereof. Accuracy of metrics thus generated will depend on accuracy of conversion protocols, as well as accuracy of initial data; therefore, use of such metrics will likely be less precise than metrics generated from utility company databases.

Time required for data collection will

vary, depending on quality and completeness of customers' records. That time can be minimized by developing clear paper and electronic forms to streamline data collection and increase its accuracy—or better still, by integrating environmental performance metrics with overall MIS.

SUMMARY

The logic underlying eco-efficiency metrics ideally should support both business goals for profit and competitive advantage, and societal goals for quality of life and a sustainable future. Eco-efficiency metrics should support both near-term and long-term advantages, and guide companies away from the traditional and deeply short-sighted notion that we must—or even can—choose one over the other.

In that vein, some of the most powerful EPIs may be more conceptual than quantitative, such as these criteria derived from Dr. Karl-Henrik Robert of Sweden's "Natural Step."

Does the action:

- Reduce dependence on underground metals, fuels, and mineral resources?
- Reduce dependence on long-lived synthetic products or molecules?
- Preserve or increase natural diversity and the capacity of ecocycles?
- Make more efficient use of resources in relation to added human value?

And some must embed environmental performance in the most mundane of business terms.

Does the action:

- Reduce production costs?
- Generate an acceptable rate of return?

Useful EPIs should enable both a company and its stakeholders to determine, accurately and consistently, how effectively they are meeting these criteria.

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GFA clients have included companies as diverse as Interface, Monsanto, Noah's Bagels, Odwalla Juice, and Sun Microsystems, and communities as diverse as Virginia's River Country and the city of Berkeley, California. (GFA wrote Berkeley's Environmental Economy strategy, winner of the 1996 Governor's Award for environment and economy.) GFA services include Integrated EcoAudits, "industrial metabolism" analysis, Natural Step training and development of Ecological Operating Systems™. GFA software tools include Business Metabolics™ environmental performance indicators software, and the EcoAudit Toolkit. ***(continued)***

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