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Notes from the Field

Environmental performance evaluation and indicators

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Abstract

This article deals with the new ISO standard ISO 14031 on environmental performance evaluation and describes its main outline as well as its link to the EU EMAS Regulation. A further development are sector specific frameworks of accounts for massbalances, shown by the example of breweries. The appendices contain more examples of environmental management and operational performance indicators. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: ISO 14031; Environmental performance evaluation; Benchmarking; Environmental management indicators; Input–output analysis; Environmental condition indicators; Environmental performance indicators; Environmental frameworks of accounts; Environmental reporting; Eco-controlling; Eco-balance

1. Introduction

Company-specific environmental indicator systems are an important tool in planning, steering and control of environmental strain, performance and costs. A comparison of indicators between previous years, sites or other firms (benchmarking) on hand, allows for an evaluation of progress and potential savings within a firm's environmental program.

Current environmental management systems, such as the EU-EMAS Regulation [1] or the ISO 14001 [2], the ISO standard on environmental management systems, require an explicit commitment for continuous improvement of environmental performance, but not the use of indicators per se. These are, however, of great importance in the definition of environmental targets and for comprehensive environmental reporting.

Accordingly, work has nearly finished on the development of a separate world wide standard by the International Standards Organization regarding environmental performance evaluation and indicators (ISO 14031 Environmental Performance Evaluation). Although it will not be published until the end of 1999, it will not depart drastically from the DIS version (Draft International Standard) which was completed in 1998, and which can only be obtained by national standardization bodies [3].

2. What is environmental performance evaluation?

Due to the new standard ISO 14031, environmental performance evaluation (EPE) is "an internal process and management tool designed to provide management with reliable and verifiable information on an ongoing basis to determine whether an organization's environmental performance is meeting the criteria set by the management of the organization".

It is important to note that this definition explicitly refers to EPE as

- A process, comparable to the environmental management systems process and
- A tool, dealing with indicator application.

An organization with an environmental management system in place may evaluate its environmental performance against its environmental policy, objectives, targets and other environmental performance criteria. An organization without an environmental management system may use EPE to assist in identifying its environmen-

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tal aspects, determining which aspects it will treat as significant, setting criteria for its environmental performance, and evaluating its environmental performance against these criteria. EPE is therefore also a tool for the initial review within the EMAS Regulation, which requests the comprehensive assessment of a site's environmental aspects and impacts at the start of the participation within the scheme.

EPE and environmental audits help the management of an organization to assess the status of its environmental performance and identify areas for improvement as needed. EPE is an ongoing process of collection and assessment of data and information to provide a current evaluation of performance, as well as trends over time. In contrast, environmental audits are conducted periodically to verify conformance to defined requirements. Examples of other tools that management could use to provide additional information for EPE include environmental reviews and life cycle assessment (LCA). While EPE focuses on continously describing the environmental performance of an organization, environmental reviews are a comprehensive first analysis of the state of environmental protection and improvement options. LCA describes the environmental performance of product and service systems over their entire life cycle.

3. The role of indicators

Indicators are used to depict the vast quantity of environmental data of a firm in a comprehensive and concise manner. They are mostly applied to set absolute material and energy data in relation to other variables in order to increase the informational value of quantitative data.

Environmental indicators have the following purposes:

- comparison of environmental performance over time
- highlighting of optimization potentials
- derivation and pursuit of environmental target
- identification of market chances and cost reduction potentials
- evaluation of environmental performance between firms (benchmarking)
- communicational tool for environmental reports
- feedback instrument for information and motivation of the workforce
- technical support for the EU-EMAS Regulation [1] and ISO 14.001 [2]

Environmental indicators offer themselves to top management, environmental managers and other departments as comprehensive and concise key data sets in a vast sea of environmental information. They provide decision makers in firms with an overview of relevant progress, but also highlight problem areas. On this basis, environmental targets can be backed up with concrete figures, which make the definition and pursuit of environmental targets controllable and verifiable. Furthermore, their connection to traditional indicators allows for the identification of potential monetary benefits.

The strength of environmental indicators lies above all in the numerical analysis of trends and year-to-year comparisons. Subject to regular evaluation and target control, environmental indicators can highlight adverse trends through environmental controlling — adopting the function of an "early warning system". Furthermore, benchmarking within a branch offers the opportunity to identify weak points and potential improvements.

4. Demands of the EU-EMAS Regulation

The measurement and monitoring of environmental performance with indicators is important for controlling a company's compliance with the requirement for continuous improvement of environmental performance. The method of the initial review, at which the relevant data of environmental aspects and impacts (raw materials, energy, emissions, waste, noise), legal requirements and the organization of environmental protection at the site are checked, vary considerably, ranging from simple checklists to elaborate eco-balances. Which data should be collected to what scope and which methods should be used to evaluate these are not discussed either in EU-EMAS Regulation, or in ISO 14031.

An environmental program should aim to arrive at concrete measures resulting from quantitative targets which have been identified through the environmental assessment. It is often observed that firms lay out measures and then try to assess their improvement potential, instead of setting targets on the basis of previous data as required, and only then decide about organizational and technical measures to be taken.

With regard to environmental audits, indicators should make it quite clear to what extent goals have been realized and achieved. Finally, the Regulation lays down rules for the publishing of environmental statements, whereby data should be presented in absolute form, as well as in relation to production units, to allow for comparison with previous years. As minimum requirements, article 5 of the EMAS-Regulation asks for the data presented in Fig. 1.

5. The ISO 14.000 series of standards for environmental management

To arrive at a world wide methodology of tools for environmental management, a separate Technical Committee TC 207 under the International Standards Organi-

	Absolute	relative
Production Output in kg, items, etc.	Production Output (PO)	
Raw material consumption	Kg	kg/PO
Energy consumption	KWh	kWh/PO
Water consumption	m3	m3/PO
Total waste	Kg	kp/PO
Waste qualities	Kg	in % of total waste
Waste water	m3	m3/PO
Air emissions	Kg	kg/PO

Fig. 1. Environmental indicators in accordance with Article 5 of EMAS Regulation.

zation was established in 1993. It was divided into various sub-committees (SCs) and workgroups, to create the series of standards 14000 which would account for all aspects of environmental management.

The SCs deal with the following items:

- SC 1 Environmental Management Systems
- SC 2 Environmental Auditing
- SC 3 Environmental Labeling
- SC 4 Environmental Performance Evaluation
- SC 5 Life Cycle Assessment
- SC 6 Environmental Management — Terms and Definitions
- EAPS Guide for the Inclusion of Environmental Aspects in Product Standards

SC 1 worked on the specification standards ISO 14.001 and the guide ISO 14.004, the requirements for the establishment of environmental management systems. ISO 14.001 is the only specification document within TC 207, which if followed, can be confirmed by the issue of a certificate. All other standards are merely guidelines, which offer and simplify methodological steps for environmental management, but do not set any technical requirements.

SC5, Life Cycle Assessment, and SC3, Eco-labeling, deal with the product oriented assessment of environmental impacts over the entire life-cycle, and how this can be communicated. Data is needed but not yet available on a firm level, whereby input–output data from material and energy flows and indicators from SC 4 should be applied. Therefore, such analysis of product life-cycles deals mainly with global environmental impacts, such as climate change and ozone level depletion, rather than with regional or site-specific effects.

SC1 and SC2 deal with the organization of firm-specific environmental protection and its regular audit. The performance data and requirements are to be supplied by SC4.

SC4 has divided the areas of environmental performance evaluation into

- environmental management system
- operational system (material and energy flows)
- condition of the environment

6. Structure and principles of ISO 14.031, guidance on environmental performance evaluation

ISO 14.031 [3] describes environmental performance evaluation as a regularly recurring process as well as placing general requirements for indicators. It also lists detailed examples for each evaluation area. The basis for environmental performance evaluation is the so-called operational system, which corresponds to an input–output analysis of material flows.

Fig. 2 (from ISO/DIS 14.031) provides the outline of the EPE process, which is also shaped like the "Plan–Do–Check–Act" management systems model. The references relate to the numbers and titles of relevant clauses in ISO 14.031.

Data used for environmental performance indicators can be expressed as absolute or relative measurements, and, depending on the their use and application, can be aggregated and/or weighted. Indicators can be classified as follows:

- absolute indicators; e.g. tons of raw material, emissions, taken from input–output analysis;
- relative indicators, where input figures are referenced to other variables such as production in tons, revenue, number of employees, office space in m^2; e.g. water per hectoliter beer, detergent per m^2;
- indexed indicators, where figures are expressed as a percentage with respect to a total, or as a percentage change to values of previous years etc.;
- aggregated depictions, where figures of the same units are summed over more than one production step or product life cycle;
- weighted evaluations, which try to depict figures of varying importance by means of conversion factors.

Data can be collected at the level of the firm, separate sites, departments, cost centers or separate machines. Normally the reference unit should be production (in tons). If this proves impossible, alternatives could be revenue, number of employees, or days of production.

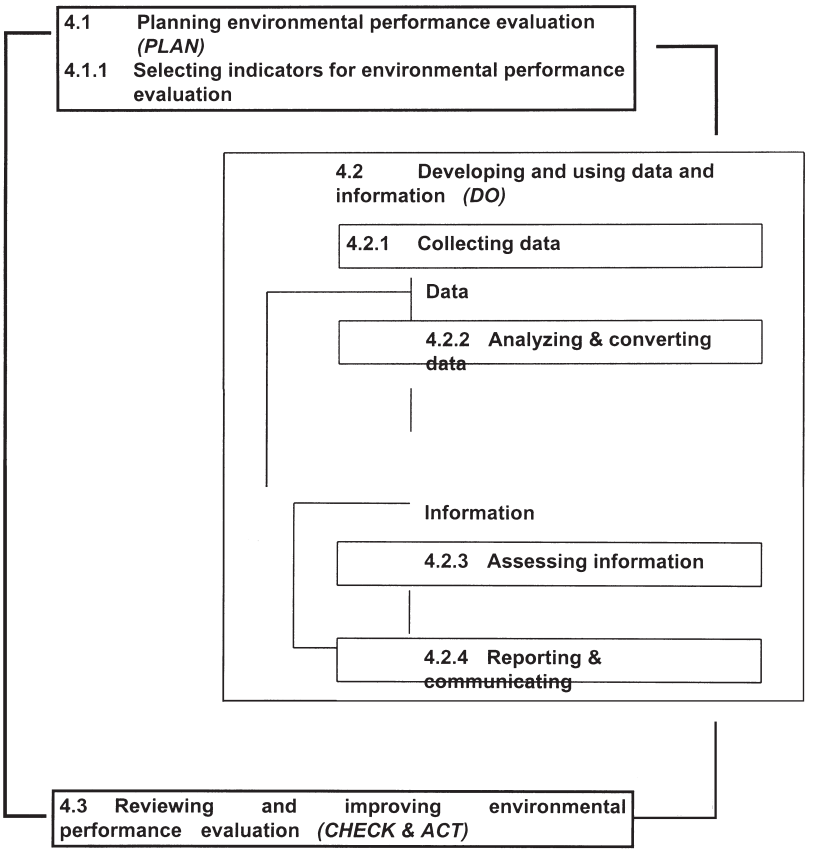

Fig. 2. The EPE process.

The choice and calculation of the reference unit is of pivotal importance to the interpretation of the data, and its feature should be clearly explained and laid down in writing, especially when comparing between sites. Even minor differences in the calculation of the number of employees (by head-count, or equivalence by part-time, number on 31.12, or average number), for example, can lead to significant distortions when comparing data.

Principles for the derivation of environmental indicators also laid down in the standard are

- *Comparability*: the indicators must be comparable and reflect changes in environmental performance.
- *Target-orientated*: the selected indicators must be chosen so they can act towards goals which are able to be influenced by the firm.
- *Balanced*: the indicators must reflect environmental performance in a concise manner, and display problem areas as well as benefits in a balanced manner.
- *Continuity*: for sake of comparison, the indicators must be derived the by the same criteria and relate to each other through corresponding time series and units.
- *Frequency*: indicators must be derived frequently enough (monthly, quarterly, yearly) so that action can be taken in due time.
- *Comprehensability*: the indicators must be understandable for the user and correspond to his information needs. The system has to be lucid and concentrate on the most important figures.

7. Types of environmental performance indicators

The standard describes two general categories of indicators for EPE:

1. environmental performance indicators (EPIs); and
2. environmental condition indicators (ECIs).

Management performance indicators (MPIs) are “a type of EPI that provides information about management efforts to influence the environmental performance of the organization’s operations. MPIs relate to the policy, people, practices, procedures, decisions and actions at all levels of the organization”.

Operational performance indicators (OPIs) are “a type of EPI that provides information about environmental performance of the operations of the organization, and OPIs relate to:

1. the design, operation, and maintenance of the organization's physical facilities and equipment;
2. the materials, energy, products, services, wastes, and emissions related to the organization's physical facilities and equipment; and
3. the supply of materials, energy and services to, and the delivery of products, services and wastes from the organization's physical facilities and equipment".

ECIs provide information about the condition of the environment which may be useful for the implementation of environmental performance evaluation within an organization.

Operational performance indicators evaluate the actual environmental aspects of firms. They are sub-divided into mass and energy indicators as taken from the input–output analysis, and infrastructure and traffic indicators. Examples include:

- electricity consumption per production unit,
- total waste
- average petrol consumption of the transport fleet.

OPIs are the basis of internal and external communication of environmental data, such as for the EU-EMAS Regulation or for the education of the workforce. Extending their application to cost analysis also allows for their use in environmental cost management.

The organization's operations include physical facilities and equipment, as well as the supply to and delivery from them. Fig. 3 (adopted from ISO/DIS 14.031) illustrates this approach.

Environmental management indicators describe the measures undertaken by the management to affect the firm's environmental impacts. Indicators such as the number of environmental audits undertaken, percentage of employees with environmental training, number of infringements against emissions quotas or number of environmentally friendly suppliers, all offer internal information on the efforts of management, yet fail to offer any information on the environmental performance or impacts per se. To rely only on management indicators for environmental evaluation would be fallacious, since they do not highlight, and in some cases even mask, the material impacts. They are, however, useful in the quantification of environmental management targets.

Environmental condition indicators describe the direct strains and impacts on the environment. For example, they can highlight the effect of air emissions on the regional air quality, or the effect of water emissions on waterways in the vicinity of a production site. Because the effects of many environmental factors, such as eutrophication, reduction in biodiversity, global warming etc. display a high interdependancy of causes (e.g. emissions of other production sites, households etc.), condition indicators are usually only applied by public institutions. Together with environmental political target setting, these national indicators can be used by firms to aid their selection of their performance indicators, as well as supporting their setting of priorities and goals. Only when a firm is the main cause of a local impact on a region, such as an airport producing noise pollution, air emission for the electricity sector or the water quality downstream for the pulp and paper sector, are these indicators to be applied by individual firms.

8. Sector-specific frameworks of accounts on the example of breweries

The basis of environmental performance indicators is the recording of mass flows on hand of the input–output analysis [7]. To arrive at logical interpretations of the data, however, system boundaries and branch-specific standard frameworks of accounts on the firm balance level have to be defined [8]. An example of such for a brewery can be seen in Fig. 4. The advantage of using a standardized account framework is that no entry can be left out, and that it allows for comparison with other sites. All environmentally relevant entries can thus be systematically investigated, and improvement potentials identified. For SMEs and newcomers to mass balancing, the most relevant items to be monitored are immediately transparent and data collection can be focused. Yearly monitoring allows for the evaluation of improvements and achievements of environmental targets. Furthermore, the most important entries can be used to derive indicators for the monitoring of environmental performance and quantification of environmental targets.

For the identification of emission sources and prevention options the attribution of data to cost centers and production process stages is of interest. Thus the firm balance is subdivided into process and production steps, again in the input–output form. The necessary data can usually be obtained from financial bookkeeping, production planning and controlling, and production flow diagrams. The next step is to assign the process emissions to the product of each production step. Material flows can therefore be analyzed either for the entire production process, or separate production steps. The most frequently used unit of analysis is not the calender year as in regular bookkeeping, but rather a unit of production referenced to overall production. Normally a harmonization of technical data with data from financial bookkeeping is not undertaken due to lack of inter-departmental communication. Experience has shown that such a consistency test would provide great optimization potentials, and has thus become a major tool in environmental controlling. Therefore it is desirable for the technical and financial bookkeeping to be executed in a compatible way.

A detailed process flow-diagram of the production

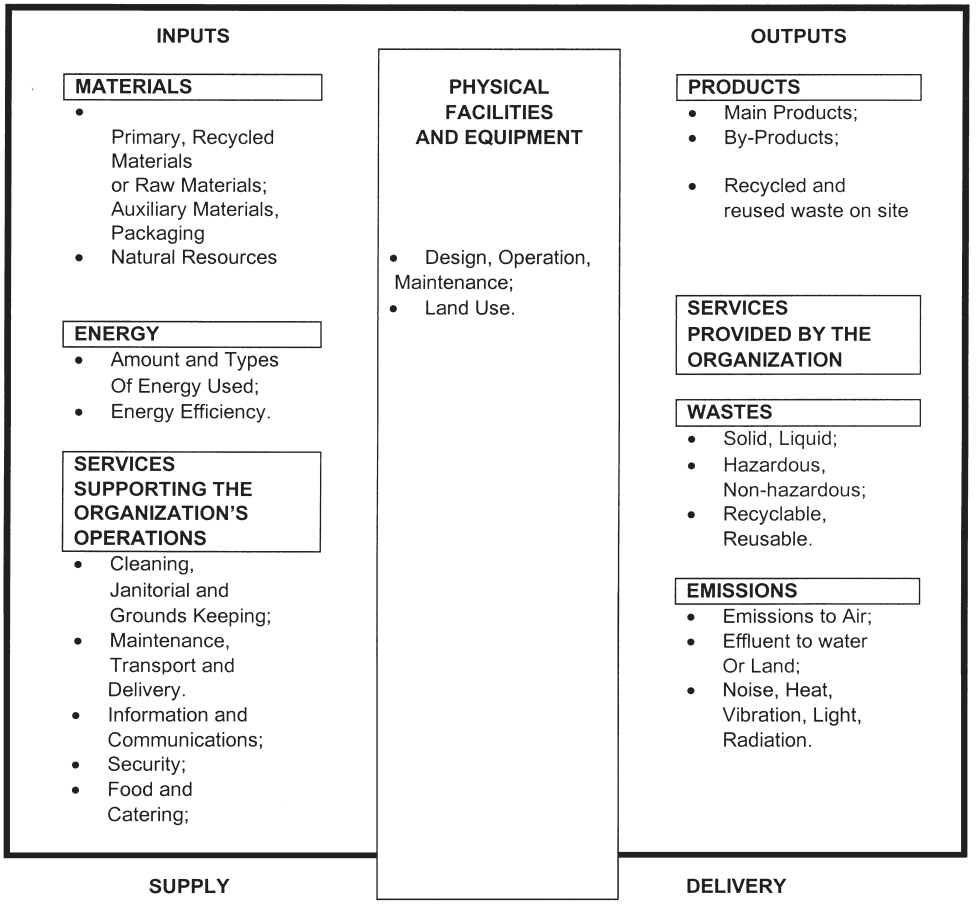

Fig. 3. The organization's operations (with additional detail).

process of a brewery is shown in Fig. 5. To allow for comparison with other sites it is essential to clearly define the system boundaries. The addition of an own malting house, or lemonade production, for example, will distort beer production data for comparison with differently organized firms. The different stages in the process flow-diagram should be consistent with the cost centers from financial bookkeeping, so that data can be obtained directly from financial bookkeeping and cost calculation.

The advantage of breweries lies in the fact that at one site essentially only one product is being produced, which allows for an easy comparison between sites using indicators. Accordingly, breweries are at the forefront of benchmarking practices, and have generally produced highly informative environmental reports. The reference unit of their indicator systems is almost exclusively hectoliters of product (beer), a reference unit harder to come by in other branches.

Indicators can be used not only internally, but also as a comparison between sites. The Austrian Brewery Union has used indicators for some years to compare production data between sites, applying indicators which evaluate costs as well as inputs. Significant deviations from the mean can be attributed to historical differences in site structures and different production cycles. Accordingly, despite the relatively homogeneous production processes, there are ideas to implement a system of indicators at the process and production line level.

9. Conclusions

World wide one can recognize a trend in environmental reporting away from purely qualitative descriptions of environmental practices towards a more comprehensive, quantitative depiction of environmental performance by the use of input–output material flow-analysis and environmental indicators [9]. The new ISO Standard 14031 on environmental performance evaluation has used the material flow model as a basis for the indicators on the operational level and thereby provided a world wide framework for methodology and understanding. Some experts claim that ISO 14031 is the better standard for environmental management systems as it is also based on the Plan–Do–Check–Act approach but focuses directly on environmental protection, cleaner production, sustainable development and communication of related achievements, without burdening companies with the demand for written procedures and system docu-

INPUT	OUTPUT
Raw materials	**Produce**
Barley	Bottled beer
Wheat	Cask beer
Other additives	Canned beer
Malt	Alcohol free drinks
Hops	**By- products**
Lemonade elements	Malt
Brewing water	Malt dust
Auxiliary Materials	Hops
Additives (beer)	Barley waste
Additives (lemonade)	Draff
Laboratory materials	Silicic acid
Packaging	**Recycled Waste**
Crates (new)	Glass
Bottles	Metal
Cans	Biodegradable
KEGs	Plastics
Palettes	Paper, cardboard, etikettes
Etikettes	**Municipal Waste**
Foils	**Hazardous Waste**
Corks	Fluorescent tubes
Screw tops	Refrigerators
Operational Materials	Oils
Cleaning materials	Oil contaminated materials
Disinfecting materials	Used colors
Neutralisers	Chemical remnants
Filters	Electrical scrap
Oils/grease	**Waste Water**
Salts	Quantity in m^3
Cooling materials	COD
Repair and maintenance materials	BOD
Workshop	Phosphates
Canteen	Nitrogen
Office	Ammonium
Energy	Biogas
Electricity	**Emissions**
Heating	CO
Gas	CO_2
Oil	SO_2
Diesel	No_x
Petrol	Noise on site
Water	Noise at night
Public Supply	
Direct Extraction	
Surface Water	

Fig. 4. Input–output framework of accounts for breweries.

mentation as required in ISO 14001. It is therefore especially relevant for small and medium sized companies.

But, for useful interpretation of the data available, the focus must be on consistent definition of system boundaries and reference units. Therefore, sector specific accounting frameworks are in development and might become mandatory reporting formats.

The EU-EMAS Regulation requires a site specific environmental statement to be published, which includes quantitative references to emissions and the use of resources (simple input–output analysis). A standard on the general requirements of environmental reporting has been published by the German Standardization Institute, DIN, with the number DIN 33922 [4]. Other guidance has been issued by several institutes and organizations, the recent most relevant being the document by the Global Reporting Initiative [5], which includes guidance on a general accepted framework for environmental reporting by FEE, the Federation des Experts Comptables, the European Chamber of financial auditors and accountants [6]. Possibly, all this will be extended to a European or International Standard in a few years.

The demand for a standardization of a framework of

INPUT	PROCESS	SIDE PROCESS	OUTPUT
Malt Energy	Grinding		Dust
Brewing water Detergent Energy	Mashing		Heat
Water Energy	Purification		Draff Heat Waste water
Hops Energy	Preparation of wort		Heat
Water Energy	Removal of hops waste		Hops waste
Water Energy Detergent Refrigerant	Cooling of wort		Warm water
Yeast Sterile Air Water Energy Refrigerant	Fermentation		Yeast Beer Carbonic acid Waste water
Water Energy Refrigerant Disinfectant	Storage		Storage dust Waste water Beer CO2
Water Energy Carbonic Acid Detergent Disinfectant Auxiliary Materials	Filtration		Waste water Filtrate Auxiliary materials
Water Energy Refrigerant Detergent Disinfectant Carbonic Acid	Pressure tank		Waste water CO2
Water Energy Detergent Disinfectant Gebinde		Bottle and Cask cleaning	Waste water Waste paper Waste glass Sludge Heat
Lemonade Raw materials Sugar		Lemonade production	
Water Energy Carbonic Acid Packaging	Bottling, Casking		Waste glass Casks Packaging Beer rest Rinsing water Residue Waste water
Department specific Inputs		Workshop, Canteen, Administration	Department specific Outputs
Fuel oil Water		Steam/Heat production	Emissions
Petrol	Transport and Delivery		Emissions

Fig. 5. Production flow of breweries.

accounts for input–output analysis is growing, as the data disclosed at the moment can hardly be compared. Because EMAS registered sites follow the NACE classification system, environmental reports theoretically could be used to arrive at branch-specific indicators. Also, the collection of data at branch and site level as for environmental reports allows for a connection to national economic-environmental accounting and evaluation of the state of the environment. An interest in a standardization of environmental reporting is, however, not the primary goal of industry representatives at the moment, but more in the focus of research and environmental politics.

Appendix A. Examples of management performance indicators

The following Appendices contain examples for environmental performance indicators, mainly taken from the annexes to ISO 14031.

A.1. Implementation of policies and programs

- number of achieved objectives and targets;
- number of organizational units achieving environmental objectives and targets;
- degree of implementation of specified codes of management or operating practice;
- number of levels of management with specific environmental responsibilities;
- number of employees that have environmental requirements in their job descriptions;
- number of employees participating in environmental programs (e.g. suggestion, recycle, clean-up initiatives, reward and recognition, or others);
- number of employees trained versus the number that need training;
- number of environmental improvement suggestions from employees;

- results of employee surveys on their knowledge of the organization's environmental issues;
- number of suppliers and contractors queried about environmental issues;
- number of contracted service providers with an implemented or a certified environmental management system;
- number of products with explicit "product stewardship" plans;
- number of products designed for disassembly, recycling or reuse.

A.2. Conformity

- degree of compliance with regulations;
- number of non-compliances
- degree of compliance with regulations by contracted service providers;
- time to respond to or correct environmental incidents;
- numbers of resolved and unresolved corrective actions;
- number of or costs attributable to fines and penalties;
- number and frequency of specific activities (e.g. audits);
- number of audits completed versus planned;
- number of audit findings per period;
- frequency of review of operating procedures;
- number of emergency drills conducted;
- percentage of emergency preparedness and response drills demonstrating planned readiness;

A.3. Financial performance

- costs (operational and capital) that are associated with a product's or process environmental aspects;
- return on investment for environmental improvement projects;
- savings achieved through reductions in resource usage, prevention of pollution or waste recycling;
- sales revenue attributable to a new product or a by-product designed to meet environmental performance or design objectives;
- research and development funds applied to projects with environmental significance;
- environmental liabilities that may have a material impact on the financial status of the organization.

A.4. Community relations

- number of inquiries or comments about environmentally related matters;
- number of press reports on the organization's environmental performance;
- number of environmental educational programs or materials provided for the community;
- resources applied to support of community environmental programs;
- number of sites with environmental reports;
- number of sites with wildlife programs;
- number of local cleanup or recycling initiatives, sponsored or self-implemented;
- favourability ratings from community surveys.

Appendix B. Examples of operational performance indicators

B.1. Materials

- quantity of materials used per unit of product;
- quantity of processed, recycled or reused materials
- quantity of packaging materials discarded or reused per unit of product;
- quantity of auxiliary materials recycled or reused;
- quantity of raw materials reused in the production process;
- quantity of water per unit of product;
- quantity of water reused;
- quantity of hazardous materials used in the production process.

B.2. Energy

- quantity of energy used per year or per unit of product;
- quantity of energy used per service or customer;
- quantity of each type of energy used;
- quantity of energy generated with by-products or process streams;
- quantity of energy units saved due to energy conservation programs.

B.3. Services supporting the organization's operations

- amount of hazardous materials used by contracted service providers;
- amount of cleaning agents used by contracted service providers;
- amount of recyclable and reusable materials used by contracted service providers;
- amount or type of wastes generated by contracted service providers.

B.4. Physical facilities and equipment; supply and delivery

- average fuel consumption of vehicle fleet;

- number of freight deliveries by mode of transportation per day;
- total land area used for production purposes;
- number of vehicles in fleet with pollution abatement technology;
- number of business trips saved through other means of communication;
- number of business trips by mode of transportation;
- land area used to produce a unit of energy.

B.5. Products

- number of products introduced in the market with reduced hazardous properties;
- number of products which can be reused or recycled;
- percentage of a product's content that can be reused or recycled;
- rate of defective products;
- number of units of by-products generated per unit of product;
- number of units of energy consumed during use of product;
- duration of product use;
- number of products with instructions regarding environmentally safe use and disposal.

B.6. Services provided by the organization

- amount of cleaning agent used per square meter (for a cleaning services organization);
- amount of fuel consumption (for an organization whose service is transportation);
- quantity of licenses sold for improved processes (for a technology licensing organization);
- quantity of materials used during after-sales servicing of products.

B.7. Wastes

- quantity of waste per year or per unit of product;
- quantity of hazardous, recyclable or reusable waste produced per year;
- total waste for disposal;
- quantity of waste stored on site;
- quantity of waste controlled by permits;
- quantity of waste converted to reusable material per year.

B.8. Emissions

- quantity of specific emissions per year;
- quantity of specific emissions per unit of product;
- quantity of waste energy released to air;

B.9. Effluents to land or water

- quantity of specific material discharged per year;
- quantity of specific material discharged to water per unit of product;
- quantity of waste energy released to water;
- quantity of material sent to landfill per unit of product;
- quantity of effluent per service or customer.

B.10. Other emissions

- noise measured at a certain location;
- quantity of radiation released;
- amount of heat, vibration or light emitted.

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