TOWARDS A COMPREHENSIVE FRAMEWORK FOR ENVIRONMENTAL MANAGEMENT ACCOUNTING — LINKS BETWEEN BUSINESS ACTORS AND ENVIRONMENTAL MANAGEMENT ACCOUNTING TOOLS

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This article develops a comprehensive framework for environmental management accounting (EMA) linking business actors and EMA tools. The proposed framework provides structure for managers to understand and assess the variety of environmental management accounting tools that have been developed to date, with the intention of encouraging their adoption. The framework systematically integrates two major components of environmental management accounting — monetary environmental management accounting (MEMA) and physical environmental management accounting (PEMA). It highlights the past/future and short long-term time dimensions of the different tools, and the regularity of information generation, before concluding with a brief discussion about choice of the most important EMA tools.

Many companies in developed countries collect, use and distribute information related to the natural environment. This reflects a fundamental change compared with a decade ago (see, e.g., Gray *et al* 1996, p. 81, Schaltegger and Burritt 2000, p. 30). There is increasing pressure from stakeholders concerned about the impact of corporate activities on the environment, and the costs of environmental impacts have risen substantially, for example, through penalties established in new environmental legislation and investments in environmentally benign processes and products encouraged by tighter environmental regulation.

Such pressures have led to the emergence of various perceptions of the concept and practices of environmental accounting (for example, Gray *et al* 1993, Schaltegger and Stinson 1994, Hamner and Stinson 1995, EPA 1995, White and Savage 1995, Gray *et al* 1996, Schaltegger 1996, Parker 1999, Burritt 1997, Adams 2000, Schaltegger and Burritt 2000). In the literature, environmental management accounting (EMA) is defined in two fundamentally different ways. In the first approach EMA is considered to be represented by internal environmental accounting using a monetary measure (see, e.g., Schaltegger and Burritt 2000). Prior research indicates that companies in Australia are poorly positioned for the collection of monetary data relevant to EMA (Parker 2000, Frost and Wilmshurst 2000, Wilmshurst and Frost 2001).

The second approach is that EMA includes monetary and non-monetary approaches to internal accounting (see, e.g., Bennett and James 1998, ECOMAC 1996, IFAC 1998, UNDSD 2000, p. 39) reflecting a somewhat more encompassing definition. To encourage broader establishment of EMA in corporate practice, development of a common perception of EMA would be beneficial

(UNDSD 2000). This article attempts to combine the main arguments contained in the two definitions and proposes a common definition of EMA. Lack of a comprehensive framework on which to map existing EMA tools hinders more widespread use and adoption, as no clear guidance is provided on which tools are pertinent for which business decision contexts and which actors might be involved. Further, movement towards agreement about what EMA is, or what it might be, is necessary for effective communication and research between academics as well as for the promotion and establishment of modern EMA approaches in practice.

Development of a comprehensive framework would help companies wishing to introduce EMA systems, and outside groups such as the United Nations that are striving to promote the introduction of corporate EMA (UNDSD 2000). Therefore, the aim of this article is to develop a basis on which to map different EMA tools. Such a foundation will facilitate the introduction of EMA and show which EMA tools meet the requirements of, and could be useful for, different business actors in different decision contexts.

THE MAIN DIFFERENCE BETWEEN CONVENTIONAL AND ENVIRONMENTAL ACCOUNTING SYSTEMS IS THAT THE LATTER SEPARATELY IDENTIFY, MEASURE, ANALYZE AND INTERPRET INFORMATION ABOUT ENVIRONMENTAL ASPECTS OF COMPANY ACTIVITIES.

CONVENTIONAL ACCOUNTING AND ENVIRONMENTAL INFORMATION

Conventional accounting systems provide separate information about monetary and physical aspects of the company's activities. These systems, expressed in monetary units, include:

- management accounting, designed to satisfy internal needs of corporate decision-makers for short-term cost and revenue, long-term investment information and internal accountability;
- financial accounting, which provides external corporate stakeholders with information about the company's dated financial position and changes in the financial position on a regular basis over specified periods;
- other accounting systems such as tax or bank regulatory accounting, intended to provide specific information, mostly for regulatory purposes.

Conventional accounting systems with information expressed in physical units include approaches such as production planning systems, inventory and material accounting systems and quality systems.

The main focus of this article is on the information needs of different types of company managers. Management accounting is, in general, "the identification, measurement, accumulation, analysis, preparation, and interpretation of information that assists executives in fulfilling organisational objectives" (Horngren and Foster 1987, p. 2) and thus focuses on internal accounting and reporting. Recently, the specific importance of non-monetary information has been recognized (Horngren *et al* 2000, p. 888): "Management accounting… measures and reports financial and non-financial information that helps managers make decisions to fulfil the goals of an organisation."

Conventional management accounting does not normally give explicit, separate recognition to company-related environmental impacts (Schaltegger and Burritt 2000, p. 77). Instead, it is mainly designed to satisfy the needs of managers

seeking information about the economic performance of the company as a basis for decision-making. Yet, from a pragmatic perspective, the critical test for any accounting system is whether it produces information, such as environmental information, that is useful to stakeholders (e.g., managers) for evaluating their own ends (Chambers 1966, p. 54, Schaltegger and Burritt 2000, p. 45). Hence, management accounting systems should be designed to satisfy the fact that different managers may require different information — including information about the environment as pressure mounts on managers to comply with tighter environmental legislation and to be aware of corporate environmental impacts on stakeholders (Schaltegger and Burritt 2000, p. 31). For example, top managers are interested in monetary information that shows material effects on shareholder value, including environmentally related impacts on the economic situation of companies. Corporate environment managers (see Parker 1999), on the other hand, are interested in various waste and pollution figures expressed in physical units and generally have no direct interest in, for example, whether the costs of pollution abatement or waste reduction measures are capitalized or considered as expenses in the monetary account.

The main difference between conventional and environmental accounting systems is that the latter separately identify, measure, analyse and interpret information about environmental aspects of company activities. In the conventional approach, this distinction is somewhat unclear. Yet, if, as suggested, environmental information is important, differences in the units of measurement, in the data quality and its sources cannot simply be neglected if purpose-oriented information is to be provided for different managers.

Environmental Management Accounting

A comprehensive framework of EMA has to be anchored in the broader concept of environmental accounting. In relation to environmental accounting, there is a wide consensus that there are two main groups of environmental impacts related to company activities (Schaltegger and Burritt 2000, p. 58):

- environmentally related impacts on the economic situation of companies; and
- company-related impacts on environmental systems.

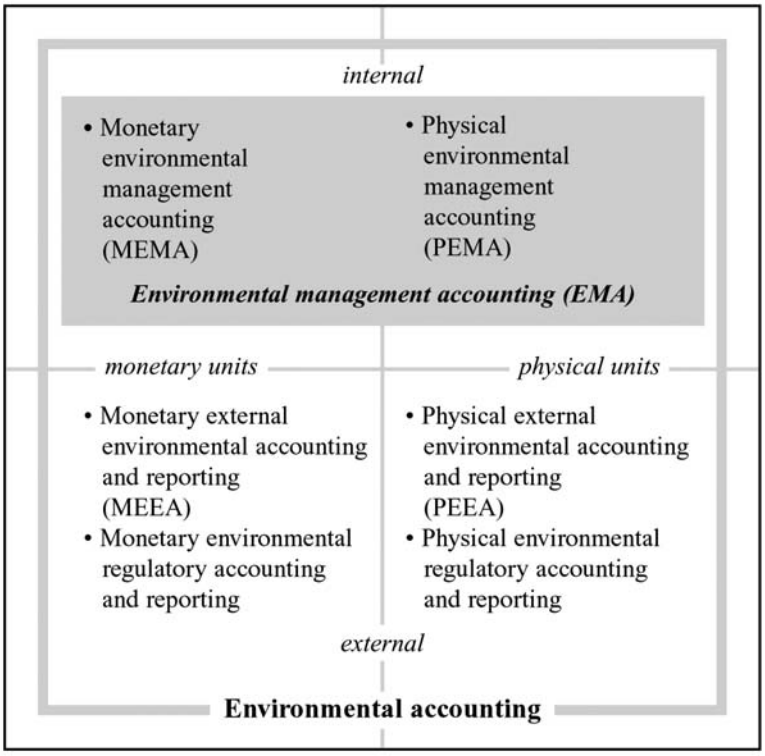
Environmentally related impacts on economic systems are reflected through *monetary environmental information*. Monetary environmental information addresses all corporate-related impacts on its past, present or future financial stocks and flows, and is expressed in monetary units (e.g., measures expressed in expenditure on cleaner production; cost of fines for breaching environmental laws; monetary values of environmental assets). Monetary environmental accounting systems can be considered as a broadening of the scope of, or a further development or refinement of, conventional accounting in monetary units, as they are based on the methods of conventional accounting systems.

Related impacts of corporate activities on environmental systems are reflected in *physical environmental information*. At the corporate level, physical environmental information includes all past, present and future material and energy amounts that have an impact on ecological systems. Physical environmental information is always expressed in physical units such as

kilograms, cubic meters, or joules (e.g., kilograms of material per customer served; joules of energy used per unit of product).

Taken together, monetary and physical environmental accounting form both environmental accounting (see the debate in, e.g., Bennett and James 1998, ECOMAC 1996, IFAC 1998 and Schaltegger *et al* 2001a) and the basis for environmental management accounting. It is proposed that EMA be defined as a generic term that includes both Monetary Environmental Management Accounting (MEMA) and Physical Environmental Management Accounting (PEMA). This is illustrated in Figure 1.

FIGURE 1: ENVIRONMENTAL ACCOUNTING SYSTEMS
(modified from Bartolomeo *et al* 2000, p. 33)



Monetary Environmental Management Accounting deals with environmental aspects of corporate activities expressed in monetary units and generates information for internal management use (e.g., costs of fines for breaking environmental laws; investment in capital projects that improve the environment). In terms of its methods, MEMA is based on conventional management accounting that is extended and adapted for environmental aspects of company activities. It is the central, pervasive tool providing the basis for most internal management decisions, as well as addressing the issue of how to track, trace, and treat costs and revenues that are incurred because of the company's impact on the environment (Schaltegger and Burritt 2000, p. 59). MEMA contributes to strategic and operational planning, provides the main basis for decisions about how to achieve desired goals or targets, and acts as a control and accountability device (Schaltegger and Burritt 2000, p. 90).

Physical Environmental Management Accounting also serves as an information tool for internal management decisions. However, in contrast with MEMA, it focuses on a company's impact on the natural environment, expressed in terms of physical units such as kilograms. PEMA tools are designed to collect environmental impact information in physical units for internal use by management (Schaltegger and Burritt 2000, pp. 61–3). According to Schaltegger and Burritt (2000, p. 261), PEMA as an internal environmental accounting approach serves as:

- an analytical tool designed to detect ecological strengths and weaknesses;
- a decision-support technique concerned with highlighting relative environmental quality;

- a measurement tool that is an integral part of other environmental measures such as eco-efficiency;
- a tool for direct and indirect control of environmental consequences;
- an accountability tool providing a neutral and transparent base for internal and, indirectly, external communication; and
- a tool with a close and complementary fit to the set of tools being developed to help promote ecologically sustainable development.

Figure 1 categorizes these environmental management accounting systems according to the two dimensions *internal vs. external* and *monetary vs. physical*.

A range of factors supports the development of this comprehensive framework of environmental management accounting. First, there is a lack of common terms describing environmental management accounting in the literature. Given the assumption that the philosophy and tools associated with environmental accounting, including EMA, can assist the drive towards a sustainable society (Schaltegger and Burritt 2000, p. 46), it is important to create a common understanding in order to facilitate its communication and promotion among managers and other stakeholders.

Second, a conceptual separation between internal and external accounting is based on the fact that the level of detail and aggregation of information and the extent of confidentiality differ between management and other stakeholders' needs. It has also been argued that a separate focus on the accounting needs of management (rather than on the needs of external stakeholders) is to be encouraged because a focus on external reporting can lead to distortions in the collection and use of information for decision-making (Kaplan 1984, see also Bennett and James 1999, p. 32).

Third, different types of managers rely on and have their performance assessed using either physical, or monetary, or both types of information. For example, managers in the corporate environmental department have various goals including:

- identifying environmental improvement opportunities;
- prioritizing environmental actions and measures;
- environmental differentiation in product pricing, mix and development decisions;
- transparency about environmentally relevant corporate activities;
- meeting the claims and information demands of critical environmental stakeholders, to ensure resource-provision and access; and
- justifying environmental management division and environmental protection measures.

Different forms of information are required to help environmental managers meet their goals, including:

- physical measures of material and energy flows and stocks and related processes and products, and their impacts on the environment;
- monetary measures about the economic impact of environmental initiatives (such as pay-back periods, return on capital/investment, etc.); and
- qualitative measures of stakeholder claims.

This contrasts with the needs of, for example, a production manager concerned with task control over operations, optimizing energy and material consumption, and reduction of environmentally-induced risks and in need of physical measures of material and energy flows and process records[5].

The need for integrating environmental with economic issues by combining them in one

[5] See the typical goals of different types of managers outlined in Schaltegger *et al* (2001b).

Figure 2: Proposed Comprehensive Framework of Environmental Management Accounting (according to Schaltegger, Hahn and Burritt 2000)

		Environmental Management Accounting (EMA)			
		Monetary Environmental Management Accounting (MEMA)		Physical Environmental Management Accounting (PEMA)	
		Short Term Focus	**Long Term Focus**	**Short Term Focus**	**Long Term Focus**
Past Oriented	Routinely generated information	1. Environmental cost accounting (eg. variable costing, absorption costing, and activity based costing)	2. Environmentally induced capital expenditure and revenues	9. Material and energy flow accounting (short term impacts on the environment – product, site, division and company levels)	10. Environmental (or natural) capital impact accounting
	Ad hoc information	3. *Ex post* assessment of relevant environmental costing decisions	4. Environmental life cycle (and target) costing Post investment assessment of individual projects	11. *Ex post* assessment of short term environmental impacts (e.g. of a site or product)	12. Life cycle inventories Post investment assessment of physical environmental investment appraisal
Future Oriented	Routinely generated information	5. Monetary environmental operational budgeting (flows) Monetary environmental capital budgeting (stocks)	6. Environmental long term financial planning	13. Physical environmental budgeting (flows and stocks) (e.g. material and energy flow activity based budgeting)	14. Long term physical environmental planning
	Ad hoc information	7. Relevant environmental costing (e.g. special orders, product mix with capacity constraint)	8. Monetary environmental project investment appraisal Environmental life cycle budgeting and target pricing	15. Relevant environmental impacts (e.g. given short run constraints on activities)	16. Physical environmental investment appraisal Life cycle analysis of specific project

category — environmental management accounting — provides a fourth driver. A major focus of EMA is to raise management awareness about the potential importance, positive and negative, of environmental impacts on corporate economic performance.

Environmentally induced monetary impacts of a company are strongly interrelated with corporate environmental performance measured in physical units. Integration can be typified through, for example, measures of eco-efficiency that combine measures of economic performance with measures of environmental impact in a ratio format (see, e.g., Schaltegger and Sturm 1992, 1998).

The scope of EMA illustrated also complements the views of authors who have canvassed the idea that companies should provide greater emphasis on the

management and measurement of non-monetary aspects of corporate performance (Johnson and Kaplan 1987, Kaplan and Norton 1996) in order to encourage a mind-set that takes the long term into account.

Finally, conventional management accounting in physical units exists independently of, and prior to, the development of EMA systems. Managers have always been concerned to improve materials and energy efficiency in order to improve economic results of their corporations. For example, productivity measures of efficiency, expressed in physical units, have long been derived in most conventional management accounting systems (e.g., material input per unit of product). The derivation of physical material and energy flows is necessary information prior to their later expression in monetary units. Consequently, much physical information derived in conventional management accounting systems is of great use in environmental management accounting. Standard costing provides a case in point, where variance analysis includes price and quantity variances to be examined in tandem, not just price (monetary) variances for management control purposes. In addition, the information contained in environmental management systems that have, hitherto, often been developed ad hoc need to be integrated into EMA. For example, internal tax planning provides a case where physical emissions of pollution are calculated first by management and then estimates of the cost of a specific environmental tax are made (e.g., a tax on carbon emissions).

Taking all these factors into account, it is possible to provide greater insight into the development of a comprehensive framework for EMA.

COMPREHENSIVE FRAMEWORK FOR ENVIRONMENTAL MANAGEMENT ACCOUNTING

Building on these arguments, which support the notions of MEMA and PEMA as core constructs in EMA, additional dimensions can also be seen as being a necessary, important part of environmental management accounting. In particular, three dimensions of environmental management accounting tools are emphasized:

- time frame — the period being addressed by different tools (e.g., past, current or future);
- length of time frame — the duration of the period being addressed by the tool (e.g., tools addressing the short term vs. those with a focus on the long term); and
- routineness of information — e.g., *ad hoc* vs. routine gathering of information.

Figure 2 includes all five dimensions — internal vs. external; physical vs. monetary classifications, past and future time frames, short and long terms, and *ad hoc* vs. routine information gathering — in the proposed framework for EMA. Any specific EMA accounting tool can be assigned on the basis of the classification scheme drawn up by these five dimensions (see the detail in Figure 2 and Schaltegger and Burritt 2000, ch. 6 for a detailed description of different EMA tools).

Time Frame

Accounting systems and associated tools of analysis, used to attach meaning to the signals produced by accounting tools, can be classified into those with a focus on the past, and those looking to the future. Rows headed “past oriented” and “future oriented”

in Figure 2 distinguish between the MEMA and PEMA tools that are available to management for addressing environmental issues with a focus either on measurement of past transactions, transformations or events or the prediction of the impact of possible future transactions, transformations or events. For example, environmental cost accounting (in the top box in the third column) provides routinely generated short-term information about the past environmental monetary impacts of activities, products, divisions, departments and the total economic entity, whereas monetary environmental operating budgeting (the third box down in the third column) projects this information into the short-term future for planning and control purposes.

Length of Time Frame

Environmental issues are generally considered to be *long term*; while management is frequently criticized for adopting a short-term perspective to appease the financial markets and one group of stakeholders in particular — shareholders. Columns headed "short-term focus" and "long-term focus" in Figure 2 distinguish between the MEMA and PEMA tools that are available to management for addressing environmental issues with either a short or long-term focus. The length of time frame associated with the discretion available to different levels of management has been highlighted by the need to emphasize length of planning periods, e.g., short-run operational budgeting expressed in monetary terms (the third box down in the third column) vs. long-run financial planning (the third box down in the fourth column), and the span of control over physical actions, e.g., short span over tactical operational decisions in physical environmental budgeting (the third box down in the fifth column) vs. a long span over strategic situations involving long-term physical environmental planning (the third box down in the sixth column).

Routineness of Information Gathering

From the viewpoint of internal management decision-making and internal accountability, both past and future-oriented approaches can be further distinguished into routinely generated information (general accounting systems that routinely produce information for management) and *ad hoc* information (specific accounting tools that produce information on a "needs" basis for particular decisions). Rows headed "*ad hoc* information"' and "routinely generated information" in Figure 2 distinguish between the MEMA and PEMA tools that are available to management for addressing environmental issues on a regular or irregular basis. For example, the PEMA tool "environmental capital impact accounting" (the first box down in the final column) provides regular information about corporate impacts on natural capital (e.g., whether critical and non-critical environmental capital has been maintained, improved or depleted), whereas PEMA information about "life cycle inventories" (the second box down in the final column) is only required on an *ad hoc* basis for the purpose of conducting life cycle assessment of new products.

By combining all of these analytical factors this article suggests a comprehensive framework for EMA within which the different tools of internal environmental accounting, MEMA as well as PEMA tools, can be placed and assigned according to the decision or internal accountability setting. Figure 2 shows that EMA encompasses a large range of different accounting approaches that serve different needs

FIGURE 3: Value chain and internal corporate EMA users (based on Porter 1985, p. 37)

depending on the decision context, purpose and management level. While detailed information about the EMA tools mentioned in the cells in Figure 2 are further discussed in the standard environmental accounting literature (see Schaltegger and Burritt 2000), the question of choice of the most important EMA tools does need further consideration.

CHOICE OF THE MOST IMPORTANT EMA TOOLS

To establish links between EMA tools and different business actors (or types of managers) it is necessary to show how the decision characteristics of EMA tools (see Figure 2) are related to different managers and the types of information that might be relevant to them. Hence, to illustrate the benefits stemming from the comprehensive framework for EMA outlined above, Figure 3 identifies specific decision-making contexts.[6] A general theoretical basis for analysis of the scope of management will be used here based on the well established value-chain approach of Porter (see Figure 3), to extend the main focus of Bennett and James (1998, p. 34) who only consider managers of accounting and finance, environment and production departments.

The value-chain approach to management functions identifies support departments and operating departments, the managers of which may need different types of environmental data when making decisions. For example, top management tends to need more aggregate information, whereas operations managers tend to need detailed, or specific, information. For each specific manager typical goals and related information needs can be identified. Figure 4 illustrates a generic set of managers that may need EMA information, the basic goals of these managers and the type of information they need. Each manager can be examined in turn, although it must be remembered that in smaller organisations a single manager may carry out several functions (e.g., production and marketing), and some functions may not be present at all (e.g., research and development).

For example, as shown in Figure 4, *top management* tends to be concerned with strategic, long-term accounting information used to plan and control activities at the corporate level. Columns four and six in Figure 2 display EMA tools that have a long-term focus and may be of particular use to top management (e.g., when there is imposition of a carbon tax on an organisation, or the introduction of a carbon-trading scheme). Because top management needs aggregate information, it looks for measures that can be used to compare a range of diverse corporate activities.

[6] Contrast, for example, this specific analysis of the link between managers and decision making characteristics related to EMA tools with Parker (1999) who makes a limited recommendation that selected environmental costs be 'grafted on' to the conventional full cost accounting system and onto the corporation's short term operational budgeting system in order to promote environmental costing within organisations.

Top managers have a preference for monetary information that uses a common unit of account and facilitates comparison between different courses of action. Hence, their emphasis is likely to be on MEMA tools that affect strategic decisions relating to monetary capital on a regular basis for the organisation, as well as on an *ad hoc* basis for appraising the performance of individual projects with environmental impacts involving large amounts of monetary capital (column four, boxes one and two). Top managers are also responsible for steering the organisation into the future. They would find routine long-term MEMA planning tools of use, e.g., related to environmentally driven research and development plans for the company, and *ad hoc* monetary environmental investment appraisal tools such as NPV using growth options for large single investments where environmental considerations play a key role.

In contrast, *divisional management* has been included as an additional column as it is accountable to top management for monetary performance and the performance of the divisions and this implies the feedback of cost and revenue MEMA results about key divisional performance measures. The emphasis is likely to be on the type of short-term routine EMA information represented in box one, column three, of Figure 2, even though long-term information is ideally considered by divisional managers.

Production managers need production-specific accounting information. Such information, related to production activities in the value chain (Porter 1980) has a tendency to be expressed in physical terms because production managers plan and control physical rather than monetary processes. Production management will tend towards the use of PEMA tools, especially short-term PEMA tools, because of their concern to keep production flowing, and to improve technical efficiency. Hence, use of material and energy flow accounting information will be a routine requirement, relating to the past for control purposes (box one in column five) and projected through physical environmental budgeting (box three in column five) for production scheduling plans.

To give another example, *product management* is mostly concerned with product-specific information. Such information has to be expressed in both monetary and in physical units because decisions related to pricing and environmental quality have to be made. Thus the *ad hoc* MEMA tool environmental life cycle (and target) costing represented in the second box down in column four of Figure 2 is of particular interest to product managers. However, they may also be interested in routinely generated environmental cost information, especially about material and energy flows. The most important PEMA tool for product managers is the past-oriented *ad hoc* life cycle inventory information which covers all of the physical environmental impacts of a product over all the stages of product life (see second box down in column six of Figure 2). In addition, product management might seek physical information on material and energy flows.

Figure 5, based on information extracted from Figures 4 and 2, illustrates the links between the managers of different business functions (the business actors), the main information focus of such managers, and the environmental information and box location of environmental management accounting tools that might be relevant in addressing environmental aspects of decision-making.

FIGURE 4: GENERIC AIMS AND OBJECTIVES OF DIFFERENT TYPES OF MANAGERS (SCHALTEGGER *et al* 2001B)

Corporate EMA System

Relevant EMA users	**Basic Goals**	**Type of Information desired**
Top Management	– Long term profitability and survival of company – Securing legal compliance with minimal cost to the corporation – Realization of all economically beneficial environmental protection measures – Securing the provision of resources from the critical stakeholders	Highly aggregated financial and strategic (qualitative and quantitative) information on the business environment and the company's performance.
Accounting and Finance Department	– Identifying and realizing cost saving potential – Transparency about cost-relevant (environment-related) corporate activities – Transparency about the impact of (environment-related) activities on the income statement and/or balance sheet – Reduction of environmentally-induced risks (Bennett and James 1998, p. 34ff.) – Compliance with accounting regulations – Maximization of shareholder value	Financial measures about corporate activities, e.g. cost-, income- and balance sheet related issues, risk assessments, investment decisions, mergers and acquisitions etc. Financial information on the value and economic performance of the enterprise.
Environmental Department	– Identifying environmental improvement opportunities – Prioritizing environmental actions and measures – Environmental differentiation in product pricing, mix and development decisions – Transparency about environmentally relevant corporate activities – Meeting the claims and information demands of critical environmental stakeholders, to ensure resource provision and access – Justifying environmental management division and environmental protection measures (Bennett and James 1998, p. 34f., UNDSD 2000, p.46)	Physical measures on material and energy flows and stocks and related processes and products, and their impacts upon the environment.
Health and Safety Department	– Safeguarding the safety, health and welfare of employees at work from environmental accidents and disasters	Physical measures of health and safety.
Quality Department	– Meeting the (environmental) product requirements of customers at the minimum cost for a given level of product quality	Information on cost of quality. Physical measures of technical product requirements.

Corporate EMA System		
Relevant EMA users	**Basic Goals**	**Type of Information desired**
Human Resources Department	– Job related (including environmental) concerns of employees – Remuneration, including rewards for good environmental performance – Physical jobs allocated and job conditions monitored	Information on financial rewards. Physical information on turnover, satisfaction, morale.
Legal Department	– Ensuring (environmental) legal compliance by the company's operations	Physical measures. Qualitative compliance information.
R&D and Design Department	– Development and design of marketable products and services – Reducing (environmental) risks of investments – Development of improved production processes	Strategic information about market demands. Financial information about costs of new products and services. Information on technical feasibility and environmental impacts of newly designed products and services.
Corporate Marketing and PR Department	– Meeting external information demands of critical stakeholders – Meeting claims and information demands of shareholders, other economic stakeholders (including those interested in environmental reports) – Developing a green image of the company and its products	Information about stakeholder claims. Physical and financial information on the company's environmental impacts and efforts for pollution reduction and prevention.
Production Management	– Task control over operations – Optimizing energy and material consumption – Reduction of environmentally-induced risks	Information on material and energy flows and process records.
Purchasing Department	– Efficient procurement of the inputs for corporate operations – Establishing and securing favorable relationships with suppliers	Information on quality and environmental properties of the goods purchased. Financial information on prices.
Logistics	– Efficient organization of, collection, storage, and physical distribution of goods and products	Physical measures e.g. on distribution means and storage facilities and related environmental impacts.
Marketing and Sales Department	– Increasing sales and attracting and satisfying buyers. – Provision of means by which buyers can purchase the product – Inducing customers to buy the enterprise's products through the tools of the marketing-mix (especially pricing, distribution, and communication)	Information on operational market conditions (e.g. pricing, competitor activities, etc.) Information on customer demands.
Disposal and Recycling	– Efficient disposal and recycling of wasted or used material – Minimization of wastes to be treated, especially hazardous wastes	Physical measures of the properties of disposable and recyclable goods. Technical information on treatment and recycling options.

FIGURE 5: MANAGEMENT GROUPS AND RELEVANT EMA TOOLS COMPARED

Corporate EMA Systems

Relevant EMA users	**Conventional rationale for link with tools**	**Relevant EMA Tools**
Top Management	Main concern is with aggregate financial and strategic information about the company's overall investment and financial performance.	- MEMA (regular and *ad hoc*, long term, past and future) - see boxes 2, 4, 6 and 8 in Figure 2.
Divisional Management	Emphasis is on divisional financial and strategic information with a focus on short term profitability measures such as return on capital employed, economic value added, and residual income.	- MEMA and PEMA (regular and *ad hoc*, long and short term, past and future) - see boxes 1, 3, 5 and 7 in Figure 2.
Accounting and Finance Department	Focus is on short and long term investment and financial performance measures of activities at the corporate, segmental and product levels, e.g. cost-, income- and balance sheet related issues, risk assessments, investment decisions, mergers and acquisitions etc. Includes measures and estimates of costs of quality, health and safety and human resources management.	- MEMA (regular and *ad hoc*, long and short term, past and future) - see boxes 1, 2, 3, 4, 5, 6, 7 and 8 in Figure 2.
Environmental Department	Emphasis on physical measures of material and energy flows and stocks and related processes and products, and their impacts upon the environment.	- PEMA (regular and *ad hoc*, long and short term, future and past) - see boxes 9, 10, 11, 12, 13, 14, 15 and 16 in Figure 2.
Health and Safety Department	Physical information about health and safety (and concern about the impact of the environment on the health and safety of employees).	- PEMA (regular and *ad hoc*, long and short term) - see boxes 9, 10, 11, 12, 13, 14, 15, 16 in Figure 2 (re environmental health and safety issues for employees).
Quality Department	Main focus is on physical information about technical product attributes, and aspects of personnel and technology that provide the customer service or product.	- PEMA (regular and *ad hoc*, long and short term, past and future) - see boxes 9, 10, 11, 12, 13, 14, 15 and 16 in Figure 2 (re environmental quality management)

Human Resources Department	Main emphasis is on short term physical information about employee numbers and types, allocation to segments of the business, turnover, satisfaction, morale and financial information about employee rewards.	- MEMA and PEMA (regular and *ad hoc*, short term, past and future) - see boxes 1, 3, 5, 7, 9, 11, 13 and 15 in Figure 2.
Legal Department	Main concern is with physical information about compliance with legislation and regulation and financial penalties for non-compliance.	- PEMA (regular and *ad hoc*, short term, past and future) - see boxes 9, 11, 13 and 15 in Figure 2 (and some concern for 1, 3, 5 and 7).
R and D and Design Department	Focus on information about the technical feasibility and environmental impacts of newly designed products, services and operations.	- PEMA (*ad hoc*, long term, future) - see box 16 in Figure 2.
Corporate Marketing and PR Department	Information about stakeholder claims. Physical and financial information on the company's environmental impacts and efforts for pollution reduction and prevention.	- MEMA and PEMA (regular and *ad hoc*, long term, past and future) - see boxes 2, 4, 6, 8, 10, 12, 14 and 16 in Figure 2.
Production Management	Main concern is with short term information about material and energy flows and production scheduling.	- PEMA (regular, short term, past and future) - see boxes 9, 11, 13 and 15 in Figure 2.
Purchasing Department	Requires information about quality and environmental properties of the goods and services purchased, and information about prices.	- MEMA and PEMA (regular and *ad hoc*, short term, past and future) - see boxes 1, 3, 5, 7, 9, 11, 13 and 15 in Figure 2.
Logistics Department	Based on physical measures e.g. on distribution means and storage facilities and related environmental impacts.	- PEMA (regular and *ad hoc*, long and short term, past and future) - see boxes 9, 10, 11, 12, 13, 14, 15 and 16 in Figure 2.
Marketing and Sales Department (and product managers)	Information on operational market conditions (e.g. pricing, competitor activities) and customer demands.	- MEMA and PEMA (regular and *ad hoc*, short term, past and future) - see boxes 1, 3, 5, 7, 9, 11, 13 and 15 in Figure 2.
Disposal and Recycling Department	Emphasis on physical measures of the properties of disposable and recyclable goods, and technical information about treatment and recycling options.	- PEMA (regular and *ad hoc*, short term, past and future) - see boxes 7, 9,11 and 13 in Figure 2.

For example, the manager of the environmental department has an emphasis on physical measures of material and energy flows and stocks and related processes and products, such as waste streams and emissions, and their impacts on the environment. EMA tools that are particularly relevant for meeting these information needs are associated with regular and *ad hoc*, short and long-term and past and future PEMA.

Overall, the integrated EMA system is designed to account in physical and monetary terms, and reflect the underlying diversity of needs of the various functional managers (e.g., accountants and environmental managers) as well as areas of commonalities (e.g., top and divisional managers).

Further exploration of the full range of tools used for management decision-making and accountability by different groups of management, and in different organisations (e.g., manufacturing, service, knowledge, non-profit and government, small companies and companies in developing countries), are not attempted here but can be used to demonstrate the applicability of the comprehensive EMA framework that has been developed above.

Outlook

There is still no precision in the terminology associated with EMA. Drawing on the existing literature, it has been argued above that there is scope for deriving an agreed, comprehensive framework for EMA. Such an opportunity depends on the recognition of:

- monetary and physical accounting systems that, separately and in combination, are of use to different types of managers in seeking to reduce environmental impacts from the activities of their organisations;
- a mapping of the tools available for EMA related to the time frame of impacts (impacts in the past, contemporary impacts, impacts in the future);
- a mapping of the tools available for EMA with the length of time frames used by different managers for analysis (short or long-term); and
- a mapping of EMA information needs with the routineness of decisions and accountability processes faced by different managers.

Among the main advantages of the proposed new framework for EMA are:

- the recognition that EMA needs to include monetary and physical measures, albeit in systems that can be considered independently of each other, or in combination;
- the mapping of tools with EMA sub-systems that facilitate particular types of decisions and internal accountability processes; and
- the incorporation of time as a key element in the classification, in order to bring stronger focus on the links between short-term and long-term monetary considerations and short and long-term ecological considerations in management decision-making.

Finally, this development of a comprehensive framework of EMA is offered as a way forward for management seeking to adopt environmental management accounting systems. A major benefit corporate managers will experience from the proposed comprehensive framework is that it considerably clarifies the concept and applicability of EMA and related tools. Once managers have a clear picture of the classification of MEMA and PEMA tools, promotion and adoption will be easier for them and therefore it will be more likely that they will adopt the appropriate tools in a particular decision-making or internal accountability setting in which environmental aspects play a part, such as:

- the extent of subsidies from government that are environmentally damaging and which may be removed in the future;
- potential corporate impacts of environmental taxes and tightening regulations designed to bring corporations closer to tracking the full cost of their activities;
- divisional impacts on environmental capital such as biodiversity and land, water and air quality;
- corporate impacts on the goal of sustainable society; and
- product and production managers taking green opportunities when these are available.

References

Adams, C.A., 2000, "Ethical Reporting Past and Future", *Management Accounting*, February: 48–51.

Bartolomeo, M., M. Bennett, J.J. Bouma, P. Heydkamp, P. James and T. Wolters, 2000, "Environmental Management in Europe: Current Practice and Further Potential", *The European Accounting Review,* Vol. 9, No. 1: 31–52.

Bennett, M., and P. James, 1998, "The Green Bottom Line", in M. Bennett and P. James (eds.), *The Green Bottom Line: Environmental Accounting for Management, Current Practice and Future Trends*, Greenleaf Publishing, Sheffield: 30–60.

Bennett, M., and P. James, 1999, "Key Themes in Environmental, Social and Sustainability Performance Evaluation and Reporting", in M. Bennett and P. James (eds.), *Sustainable Measures: Evaluation and Reporting of Environmental and Social Performance,* Greenleaf Publishing, Sheffield: 29–74.

Burritt, R.L., 1997, "Corporate Environmental Performance Indicators: Cost Allocation — Boon or Bane?" *Greener Management International,* Vol. 17, Spring: 89–100.

Chambers, R.J., 1966, *Accounting, Evaluation and Economic Behaviour,* Scholars Book Co., Houston, Texas.

Ecomac, 1996, "Synreport: Eco-Management Accounting as a Tool of Environmental Management" (the Ecomac project), EIM Small Business Research and Consultancy, http://www.eim.nl/uk/nl/ecomac.html.

EPA (US Environmental Protection Agency), 1995, *Introduction to Environmental Accounting*, Washington D.C.

Frost, G.R., and T.D. Wilmshurst, 2000, "The Adoption of Environment Related Management Accounting: An Analysis of Corporate Environmental Sensitivity", *Accounting Forum,* Vol. 24, No. 4: 344–65.

Gray, R.H., J. Bebbington and D. Walters, 1993, *Accounting for the Environment,* Chapman Publishing, London.

Gray, R., D. Owen and C. Adams, 1996, *Accounting and Accountability. Changes and Challenges in Corporate Social and Environmental Reporting*, Prentice-Hall, London.

Hamner, B., and C.H. Stinson, 1995, "Managerial Accounting and Environmental Compliance Costs", *Journal of Cost Management:* 4–10.

Horngren, C., and G. Foster, 1987, *Cost Accounting: A Managerial Emphasis*, 6th edn., Prentice-Hall, Englwood Cliffs, NJ.

Horngren, C., G. Foster and S.M. Datar, 2000, *Cost Accounting: A Managerial Emphasis,* 10th edn., Prentice-Hall, Englwood Cliffs, NJ.

IFAC, 1998, "Environmental Management in Organisations. The Role of Management Accounting", Financial and Management Accounting Committee, International Federation of Accountants, Study No. 6, New York, March.

Johnson, H., and R. Kaplan, 1987, *Relevance Lost: The Rise and Fall of Management Accounting,* Harvard Business School Press, Cambridge, MA.

Kaplan R.S., 1984, "The Evolution of Management Accounting", *The Accounting Review*, Vol. LIX, No. 3: 390–418.

Kaplan, R.S., and D. Norton, 1996, *The Balanced Scorecard,* Harvard Business School Press, Cambridge, MA.

Parker, L., 1999, "Environmental Costing. An Exploratory Examination," *Australian Society of Certified Practicing Accountants,* Melbourne, February.

Parker, L., 2000, "Environmental Costing: A Path to Implementation," *Australian Accounting Review*, Vol. 10, No. 3: 43–51.

Porter, M.E., 1985, C*ompetitive Advantage — Creating and Sustaining Superior Performance,* Free Press, New York.

Schaltegger, S., 1996, *Corporate Environmental Accounting*, John Wiley, London, with contribution by K. Müller and H. Hindrichsen.

Schaltegger, S., and R.L. Burritt, 2000, *Contemporary Environmental Accounting — Issues, Concepts and Practice,* Greenleaf Publishing, Sheffield, UK.

Schaltegger, S., and C. Stinson, 1994, "Issues and Research Opportunities in Environmental Accounting", discussion paper No. 9124; Wirtschaftswissenschaftliches Zentrum [WWZ], Basel.

Schaltegger, S., and A. Sturm, 1992, "Eco-Controlling. An Integrated Economic-Ecological Management Tool", in Koechlin and Müller (eds.), *Green Business Opportunities. The Profit Potential,* Pitman/Financial Times, London: 229–40.

Schaltegger, S., and A. Sturm, 1998, *Eco-Efficiency by Eco-Controlling*, Vdf, Zürich.

Schaltegger, S., T. Hahn and R.L. Burritt, 2000, "Environmental Management Accounting — Overview and Main Approaches", Centre for Sustainability Management at the University of Lueneburg, Germany.

Schaltegger, S., T. Hahn and R.L. Burritt, 2001a, "Environmental Management Accounting — Overview and Main Approaches", in M. Bennett and J.J. Bouma (eds.), *Environmental Management Accounting and the Role of Information Systems.*

Schaltegger, S., T. Hahn and R.L. Burritt, 2001b, "EMA-Links — The Promotion of Environmental Management Accounting and the Role of Government, Management and Stakeholders," Centre for Sustainability Management at the University of Lueneburg, Germany.

UNDSD, 2000, "Improving Governments' Role in the Promotion of Environmental Managerial Accounting," meeting document for the First Expert Working Group, United Nations Division for Sustainable Development, Washington DC.

White, A.L., and D.E. Savage, 1995, "Budgeting for Environmental Projects: A Survey", *Management Accounting,* October: 48–54.

Wilmshurst, T.D., and G.R. Frost, 2001, "The Role of Accounting and the Accountant in the Environmental Management System," *Business Strategy and the Environment*, Vol. 10: 135–47.

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