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Tapping environmental accounting potentials of beer brewing Information needs for successful cleaner production

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ABSTRACT

Improving established production processes towards Cleaner Production can be a demanding challenge as the actors involved in these processes – both management and technical staff – often need a fresh perspective on how business and the business environment are developing. Whether existing potentials are effectively and efficiently uncovered largely depends on the availability of information as well as on knowing how to make use of it. An often observed problem is the lack of tools to obtain useful Cleaner Production information efficiently. Against the background of a case study of a major Vietnamese beer producer, this paper highlights the importance of decision-making information and demonstrates how considerable performance improvement potentials can be uncovered using environmental management accounting (EMA) techniques and tools. Particular attention is paid to the information needs of the various users of such information and how these needs can be fulfilled. The analysis of the results suggests a pattern of action that increases the efficacy and efficiency of information management and use in corporate practice.

1. The role of information in improving economic and environmental performance

An inherent objective of conventional management activities is to (continuously) improve the economic efficiency of the company. Environmental management in turn aims at improving environmental performance which ideally should result in economic improvements at the same time. Empirical research indicates that significant efficiency improvement potentials exist with regard to both, environmental and economic performance, particularly in the producing industry (e.g. Jasch, 2009; Schaltegger et al., 2008; Hallstedt et al., 2010).

In this context, Cleaner Production (CP) has shown to be a valuable approach to improving economic performance by considering the impacts of the business on the environment and vice versa (e.g. Hobbs, 2000). Although various approaches exist for CP (Jasch, 2006), their applicability depends on available and retrievable information in the company where CP is applied. However, managers pursuing CP often seem to be hindered by the lack of tools which provide information and support decision making. A major challenge is thus the acquisition and interpretation of available CP information (see e.g. Jasch, 2006).

Although the information availability problem is generic and applies to corporate practice as a whole (e.g. Scavone, 2006), in-depth research on information needs of decision makers has developed only recently (e.g. da Silva and Amaral, 2009). To better understand the environmental and economic information needs of decision makers and how these needs can be met by internal information providers an environmental management accounting (EMA) framework has been proposed by Burritt et al. (2002). This framework distinguishes 16 different types of decision situations, based on core attributes of the information used such as time frame and routineness of generation. However, this framework, like the multitude of proposed environmental accounting tools, does not explain the processes how corporate decision makers design their environmental information management and use processes.

Against the background of a case study conducted in the Vietnamese beer brewing facility of *Sai Gon Beer*, this paper focuses on the challenge of identifying what information can serve the needs of managers in the course of applying CP and how relevant information can be provided at a minimum cost. For a discussion of the case study approach in general see Yin (2009), in management accounting research see e.g. Kaplan (1986), Parker (1994) or Ryan et al. (2002), and in EMA see e.g. Burritt et al. (2009) or Gale (2006). In particular, this case study looks into the decision

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situations that arise when applying material and energy flow accounting for corporate decision making and identifies suitable tools for providing the required decision-making information as well as for reducing the cost of doing this. The example of a Vietnamese company is particularly interesting as various authors have outlined the higher potential of CP for economic and environmental improvement of activities in developing countries (e.g. Burritt et al., 2009). The higher potentials have been explained with external (e.g. economic and political conditions) and internal factors such as lack of know-how and resources (e.g. Lee et al., 1999). This paper focuses on internal factors.

Section 2 provides an overview of different EMA decision situations, discusses the settings of doing research in developing countries, and explains the relevance of analysing improvement potentials of beer production. Section 3 presents the methods and the research approach adopted. The core of this paper is Section 4, which demonstrates how EMA was used to support the process of designing and implementing CP at the case study company and what can be learned from the case. Section 5 concludes with the main implications and observations in applying EMA tools to support CP.

2. Different CP information needed in different decision situations

2.1. EMA as a set of different tools

To design and implement CP, managers need information which relates to their decision situations. In this context, environmental management accounting (EMA) embraces a wide set of tools of environmental information management which support different decision situations. The multitude of EMA tools is classified by the EMA framework (Burritt et al., 2002) which systematically integrates two major components of EMA: monetary environmental management accounting (MEMA) addressing environmental aspects of corporate activities expressed in monetary units, and physical environmental management accounting (PEMA) measuring and analysing a company's impact on the natural environment, expressed in physical units (Fig. 1). To support business actors the framework identifies different EMA tools for various decision situations, according to (cp. Burritt et al., 2002):

		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/ Present Orientated	Routinely generated information	1. Environmental cost accounting	2. Trend analysis of environmentally induced [driven] costs, revenues, etc.	9. Material and energy flow accounting	10. Environmental (natural) capital impact accounting
	Ad hoc information	3. *Ex post* assessment of relevant environmental costing decisions	4. Post-investment assessment of individual projects	11. *Ex post* assessment of short term environmental impacts	12. Post-investment assessment of physical environmental investment appraisal
Future Orientated	Routinely generated information	5. Monetary environmental operational and capital budgeting	6. Environmental long term financial planning	13. Physical environmental budgeting	14. Long term physical environmental planning
	Ad hoc information	7. Relevant environmental costing	8. Monetary environmental project investment appraisal	15. Relevant environmental impacts	16. Physical environmental investment appraisal

Fig. 1. EMA framework (Burritt, et al., 2002, p. 42) including EMA tools applied at Sai Gon Beer (shaded).

- the type of information – monetary or non-monetary (physical) information;
- the time frame – past or future: looking at whether the focus of the decision is oriented towards measuring past performance or making decisions for the future;
- the length of time frame – short or long term: whether the decision setting involves strategic information concerning several years or whether it is more operational, thus covering a shorter period such as months, weeks or days, and
- the routineness of information provision – regular or ad hoc: whether the required information is gathered regularly for a recurring purpose or only when required, e.g. to support a specific and non-recurring need.

The framework serves for conceptual classification purposes but also provides a pragmatic structure for the identification of the appropriate EMA tool for any given corporate decision setting. It can therefore serve as a basis for managers and staff to reflect whether an EMA tool already in use is the most appropriate one for the intended decision-making purposes.

From an organisational and methodological point of view, environmental aspects have often been dealt with in parallel organisational structures and departments separate from conventional business management (Schaltegger and Burritt, 2005). This detachment of environmental responsibilities can result in inadequate attention of complementarities and conflicts with other parts of the organisation (e.g. Herzig et al., 2006). Furthermore, it can lead to a total or at least partial failure to address environmental issues (ibid.).

With its concepts and tools, EMA may provide a good starting point for a successful integration in the organisation. EMA tools offer the opportunity to analyse the environmental impacts of the company on the natural environment, and address the environmentally driven monetary impacts on the company. By linking environmental issues with conventional management tools, EMA avoids the establishment of environmental management systems and tools which are rarely connected with day-to-day business and which run parallel to already existing corporate management systems. Furthermore, whereas it may seem to be a luxury privilege of developed countries to discuss the optimal choice of EMA tools to support CP, the same issues can be a question of economic and environmental survival in developing countries.

2.2. CP research in developing countries

Developing countries face greater difficulties in implementing CP than developed countries (e.g. Gale, 2006) because they usually do not have the institutional capacity in place to promote environmental protection, or to encourage the inclusion of environmental costs in decision making (Davy, 1997, p. 179; Burritt et al., 2009). A growing part of global industrial production takes place in Southeast Asia. This is particularly true for, amongst others, globally traded goods such as textiles, electronic goods and plastics (cp. CIA, 2011 for statistics on Southeast Asian countries).

With the accompanying production growth of food, paper, and mobility for domestic consumption, the Southeast Asian region is characterised both by rapid economic growth and increasing environmental problems. Countries in the region have shown substantial annual economic growth rates in recent years, boosting purchasing power and consumption along with significantly increasing energy consumption, traffic volume, waste disposal, and environmental impacts (ibid.). Decoupling environmental impacts from economic growth, a prerequisite for sustainable development (Weizsäcker et al., 1997), seems to be a distant prospect as "incremental improvements in environmental regulatory policy typically have been over-ridden by the scale effects of increased production, consumption and resource use" (Angel and Rock, 2003, p. 4).

A typical example of this development is the Vietnamese beer industry with its rapid growth of production and consumption. The annual beer output grew from 8.7 million hl in 2002 to 17 million hl in 2006, an annual growth rate of 18%. The Ministry of Industry announced plans to double this output by the end of 2010 up to 35 million hl, and predicted a beer consumption of 28 l per capita, expecting it to double compared to the 2006 consumption of 15 l (cp. Mekong Securities, 2007; Datamonitor, 2008; Timberlake, 2010). This fast growth of the beer industry has been fostered by the Vietnamese government by privatising the biggest breweries prior to encouraging international brewing companies such as Carlsberg and Anheuser Busch to establish joint ventures as the Vietnamese laws do not allow for 100% foreign investment (Mekong Securities, 2007).

2.3. Beer: untapped economic and environmental potential in production

Beer was one of the first good whose production was mechanised during the industrial revolution. In comparison to pharmaceutical, petrochemical or other industrial products, brewing beer is usually not considered to be particularly harmful to the environment since it uses only natural ingredients – typically malt, barley, hops and water. However, a closer look at the environmental life cycle of beer reveals its environmental importance (Cordella et al., 2008; Narayanaswamy et al., 2005; Talve, 2001). By far the largest ecological impacts are caused by agricultural processes to produce the basic ingredients of beer. According to Talve (2001, p. 297, Table 3), the agricultural production contributes almost 80% to the total environmental impact of the beer life cycle, followed by transportation (~8%), production of auxiliaries (~6%), and beer production (~5%). From a life-cycle perspective, brewers are not the focal point for environmental improvement: "[…] beer production did not seem to be a problematic activity, consistent with the widely held opinion that breweries have to be considered as small energy consuming and less polluting companies in the industrial sector" (Cordella et al., 2008, p. 137).

Numerous life-cycle assessment (LCA) studies on beer production, however, conclude that certain aspects of beer production have a significant environmental impact, in particular in terms of energy consumption and the related environmental contribution to global warming. A weighted assessment of all environmental impacts by Talve (2001, p. 297, Table 3) shows that the global warming contribution (GWC) is the most important environmental impact of brewing, contributing to roughly one third of the overall life cycle's GWC. Given that other life-cycle steps are more important in general and energy use is the crucial issue for brewers, Cordella et al. (2008, p. 139) arrive at the following recommendations for environmental management measures of breweries:

- "monitoring, registering and analysing the input and the output streams of the brewery system;
- choosing carefully the suppliers, especially those of barley and glass bottle;
- improving energy saving policies;
- optimizing solutions for the product delivery;
- setting up marketing strategies in favour of reusable packaging rather than non-returnable ones".

This paper thus investigates the use of EMA for applying a CP methodology in optimising beer production. From a global perspective, beer consumption and production is decreasing in developed countries but increasing strongly in many developing countries (Timberlake, 2010; Talve, 2001). This is why CP and the measurement of environmental impacts and related economic effects are of major relevance for the beer production in developing countries with a high growth in beer production, and often with shortages of electric power, water, and raw materials.

3. Research approach

The analysis conducted in Section 4 is based on the results of a four-year case study research project on environmental management accounting in Southeast Asian small and medium-sized companies. Beside their wide-spread application for teaching purposes, case studies have become quite common in management accounting research in general (Ryan et al., 2002) and in EMA research in particular (e.g. Burritt, 2004).

This case study based project investigated the applicability of EMA tools for management decision making and accountability by different groups of management, and in different organisations. Based on the EMA framework (Burritt et al., 2002) the project analysed the process of establishing environmental information management with EMA tools. In total 16 in-depth company case studies were conducted in Indonesia, the Philippines, Thailand and Vietnam. These case studies were designed to contribute to a comparative research (Yin, 2009) analysing decision-making situations and potentials for EMA implementation in businesses in developing countries. In addition, factors influencing the application of EMA tools were analysed. Thus this case study of the Vietnamese beer brewer *Sai Gon Beer* dealt with here, is embedded in a broader context of exploring different decision situations. Given the higher proportion of energy and material costs (due to lower labour costs compared to industrialised countries) to the overall costs in Vietnamese settings, it was expected that applying CP is likely to result in relatively high economic and environmental performance improvement.

The case study research design was chosen to better understand complex decision-making processes and contexts and to examine and explain their outcomes. This case-orientated approach analyses the specific types of environmental data which managers of various business functions may need when making decisions in different decision situations.

Based on the EMA framework the specific decision-making context of the company was analysed to identify the most suitable EMA tool(s). This was done by asking company managers about their decision situations and information needs. The managers were not aware of the EMA framework until the case study was finalised. Rather than elaborating on the usefulness of specific EMA methods for various businesses, the research approaches EMA by focussing on the needs and the specific decision situations company managers face. This approach helps explore current practice, increase the benefit of EMA for management and meet the reality of management accounting, where internal decisions about varied and rather different issues have to be prepared, assessed, and made independent of predefined systems or standardised tools.

To capture a wide range of phenomena and for the purpose of data triangulation, the study drew from multiple data sources including:

- a large spectrum of contact persons (environmental, production, and financial managers, accountants, representatives from environmental and industry associations such as, for instance, chambers of commerce);
- a variety of research methods (direct observation, documentation, archival records, interviews, and questionnaires);
- different groupings of researchers (interviewing and observing in pairs) and
- various cases within and between sectors (e.g. electroplating, food, paper and pulp, etc.).

The case studies were conducted with the help of so-called ‘local resource persons’ who were involved in conducting the case studies to promote EMA in Southeast Asia. These were mainly environmental management and engineering consultants as well as trainers multiplying EMA knowledge and experience they gained from the case studies. The following case study of *Sai Gon Beer* illustrates the EMA approach to identify CP potentials in beer brewing, its strengths and weaknesses.

4. Applying EMA for CP

4.1. The case of Sai Gon Beer

Sai Gon Beer was established as an equity joint venture of one of the largest and former state-owned brewing companies and a newly privatised Vietnamese import–export company, with a total capital investment of roughly € 5 million. The joint venture company started its production of bottled and barrelled beer in 1999. Employing some 200 people, the brewery has increased beer output year by year up to almost 200,000 hl/a, with plans to grow further. This required the construction of an additional brewing facility which was in planning when the case study was conducted.

The management considers *Sai Gon Beer* to be an “environmental flagship company” of central Vietnam. The company uses state-of-the-art brewing equipment and has implemented an environmental management system which led to proper waste separation, recycling of broken bottles and other materials, wastewater treatment, etc. Consequently, *Sai Gon Beer* was certified in accordance with ISO 9001 and ISO 14001 and does not face any legal penalties relating to environmental issues. It has won several Vietnamese quality awards for its products. Furthermore, as stated in its environmental management report, the company is motivated to reduce its environmental impacts such as the use of water, energy consumption, noise, dust, and pollutants in effluent wastewater.

The production facilities of *Sai Gon Beer* were constructed in 1998. Almost the entire brewing equipment was imported from German suppliers and installed by a German engineering company. Beer is filled in bottles and kegs and delivered to retailers with a small portion going to large customers such as restaurants in the Tuy Hoa province. The company operates a return system for bottles and kegs, i.e. empty bottles and kegs are collected, sorted and washed.

The main production steps include grinding (of malt and rice), brewing, fermentation, filtration and storage, and keg and bottle filling. All steps include various detail processes and activities. Unlike most European and North American breweries, *Sai Gon Beer* uses rice instead of barley as one of the main beer ingredients. Important supply or utility processes from an environmental point of view include chilling, air compressing, heat supply (boiler), and wastewater treatment. These activities require facilities and devices such as the office building, the air conditioning system of the factory building, etc.

4.2. In-plant assessment

As a first impression of its economic performance, *Sai Gon Beer* provided the budgeted and the actual figures for sales and net profit (Table 1). While the company met its sales targets, it failed to meet the net profit target. The accounting department identified the main culprit: higher than expected operational expenses on raw materials and energy.

Table 1
Sai Gon Beer sales and profit.

Sai Gon Beer	Budget figure	Actual figure	Actual performance relative to target
Sales	200,000 hl	203,000 hl	101.5%
Sales	7,250,000 €	7,299,100 €	100.7%
Net profit before taxes	475,600 €	180,000 €	37.8%

Given *Sai Gon Beer*'s ISO 9001 and ISO 14001 certification, its quality awards, and its up-to-date equipment, a state-of-the-art brewery was to be expected. The production manager, though, was alarmed by international benchmark figures for electricity and water consumption of beer brewing as he noticed that the company was performing poorly. In fact, he observed that the total water and energy demand per unit beer produced was at least twice as high as the international benchmark figures. Hence, to get a better idea of the drivers of energy and water consumption and to develop improvement options, the production manager emphasised his interest in applying EMA. Interestingly, the manager had a focus on the improvement of physical performance, anticipating that this would also positively affect financial performance. Furthermore, both the production the environmental managers were keen to link these physical performance issues to environmental management activities, to support continual improvement as required by their environmental management system. Both managers showed a strong interest in monitoring performance on a regular basis and gathering ideas for the new plant, which was being planned.

The analysis of the decision situation based on the EMA framework (Fig. 1) showed that the managers searched for information that:

- is generated routinely (to monitor improvements in performance);
- relates to the past (consumption of previous month, year, etc.);
- takes a short term perspective (monthly or at least on an annual basis) and
- is measured in physical units.

The decision-making situation is therefore linked to Box 9 of the EMA framework (cp. Fig. 1) and, in part, to Box 1 of Fig. 1 as any improvement in energy and water efficiency has regular financial consequences period by period. Taking the plans for a new plant into consideration, a long term, future-oriented perspective was also considered relevant for *Sai Gon Beer*'s long-term decision making (Boxes 8 and 16 of the EMA framework in Fig. 1). Although these decision situations were stated clearly by the managers, they nevertheless focused on current plant performance. As a matter of course, any conclusions drawn from the assessment of current operations would be included in the planning process for the new plant (Boxes 6 and 14 in Fig. 1).

To fulfil the environmental and production managers' need for information and to obtain a better understanding of *Sai Gon Beer*'s operations in general as well as the drivers of environmental performance in particular, a material and energy flow accounting (MEFA) system (Fig. 1, Box 9) was agreed upon.

MEFA is a physical accounting approach (e.g. Jasch, 2009; Burritt et al., 2002) which allows creating material and energy balances. It serves to calculate consumption and production figures and is thus also an essential basis for costing, while also being useful for dimensioning and designing facilities and equipment (e.g. Schmidt, 2010; Schaltegger and Burritt, 2000). Especially with increasing production costs resulting from rising resource prices, the inefficient use of materials often causes hidden costs which can easily account for 10–15% of the total economic value of produced goods (Schmidt, 2010). Applying MEFA helps to bridge between engineering and economics and to systematically identify and realise economic and environmental benefits. It is therefore not surprising that MEFA has developed as an important basis for economic and ecological assessments alike in many areas of business (For an overview on MEFA and its current status of research, see Ayes, 2010; Jasch, 2009; Prasad and Calis, 1999). In production logistics for example, it serves as the basis for planning production facilities or for improving manufacturing cycles.

The MEFA system at *Sai Gon Beer* was linked to financial performance (Fig. 1, Box 1) and assessed in terms of options for improvement (Fig. 1, Boxes 8 and 16). The database required for establishing material and energy flow accounting was comparatively good; i.e. most data was available, but scattered among different sources. The accounting, environmental management, quality management, and engineering/production departments all contributed some data.

Thus, the following main production steps were considered for the MEFA (Fig. 2):

- grinding (or milling) – malt and rice are crushed into smaller pieces;
- brewing – the grist (ground material) is mashed (mixed with water), heated up and mixed with hop in kettles, and finally cooled down. A by-product generated during brewing is trub, which can be used as farmland fertiliser;
- fermentation – yeast is added to convert sugars into alcohol in order to produce unfiltered (also called young or green) beer;
- filtration and storage – fermentation continues at slow speed and low temperatures to remove undesired compounds. The beer is then filtered through diatomaceous earth to take out yeast and other leftovers;
- bottling – beer is mainly bottled into 33 cl bottles. This step also includes pasteurisation of filled beer bottles and cleaning of returned bottles and
- barrelling – beer is filled into kegs (barrels) of various sizes, e.g. 30 l, 50 l, and 100 l.

In addition to these production steps, several supply processes were identified as relevant:

- steam supply – fuel oil is burned in a boiler to generate steam;
- air supply – an air compressor run by electric energy provides the required air pressure;
- chiller – electric energy is used to provide cooling for several production steps;
- wastewater treatment – all wastewater is collected and treated bio-mechanically before being disposed of into the public sewage system and
- other facilities – this includes the electricity demand of offices, the factory building air conditioning and other overhead electricity consumption.

For all of the above processes, input–output tables were created listing the inputs of energy (electricity, steam, compressed air, cooling), water, raw materials, and intermediates as well as outputs of intermediates, products, solid wastes, wastewater, and other items. Input–output tables covered a period of six months, but were averaged to one month to assist comparison. Finally, inputs and outputs of each process were mapped onto a production flowchart using Sankey diagrams which enabled the depiction of flows in terms of physical proportionality (cp. Schmidt, 2008).

Fig. 2 depicts the average monthly material and energy flows of *Sai Gon Beer*. The supply process of wastewater treatment was not considered since its energy demand is negligible and the bio-

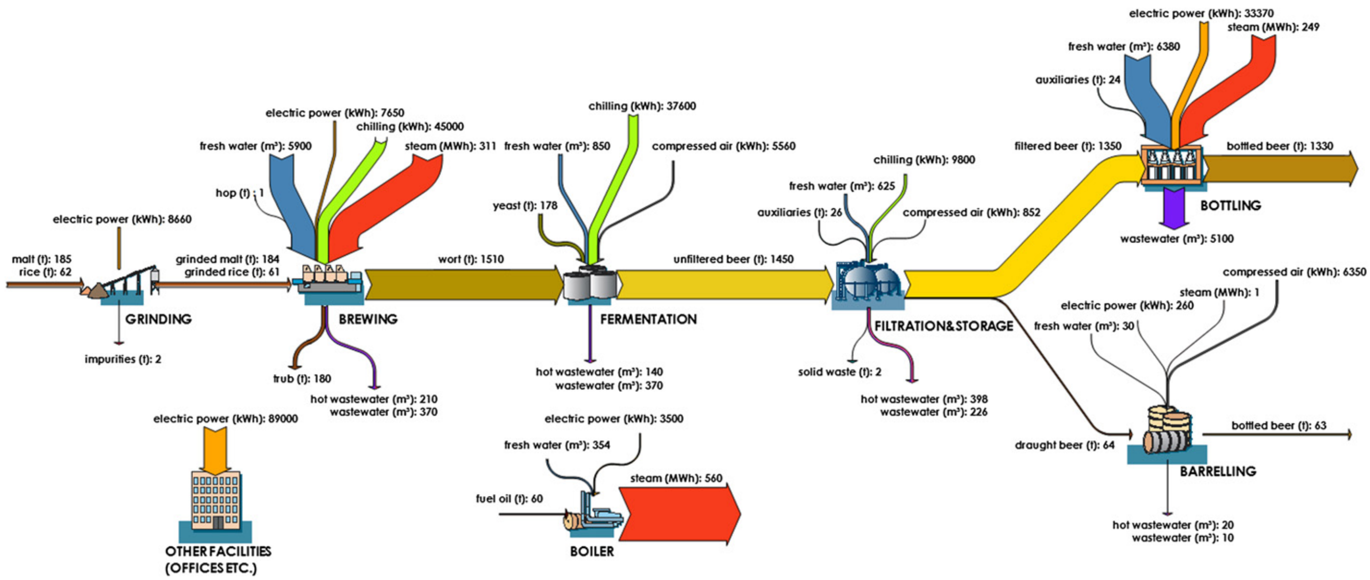

Fig. 2. Sai Gon Beer material and energy flowchart (monthly average).

mechanical treatment processes fulfil all legal requirements for wastewater treatment. The main input to the chiller and the air compressor is electric energy. The electricity demands of air compressors and chillers were allocated to the various production steps, neglecting any inefficiency within the devices as the electricity consumption of those devices was known, but not the distribution to the production steps. The distribution was estimated on the basis of the appliances' nominal power consumption.

All mass flows (in metric tonnes) are depicted proportionally, i.e. the width of a flow of two tonnes is exactly twice the width of a flow of one tonne. Accordingly, this applies for volume flows (in m^3). For energy flows an exception is made. The flows for steam (in MWh) are not proportional to all other energy flows (in kWh) because the magnitude of the steam flows would otherwise graphically dominate all other flows.

The overall relevance of steam for the energy-related environmental performance is highlighted in Figs. 3 and 4. Fig. 3 depicts the total energy demand of all production steps and other facilities while Fig. 4 shows the resulting Global Warming Contribution (GWC) for each of these steps. The GWC was calculated based on the following conversion factors:

- the GWP for electricity is 0.7 kg CO_2-equivalent per kWh. This value was computed on the basis of the Vietnamese electricity mix (roughly 50% hydro and 50% fossil fuel power, cp. EIA, 2007) using Ecoinvent data sets (SCLCI, 2010) and
- the GWP for fuel oil is 3.15 kg CO_2-eq. per kg (ibid.), i.e. 0.34 kg CO_2-eq. per kWh of steam at *Sai Gon Beer*.

Physical information assumed the main interest of *Sai Gon Beer*'s production and environmental managers, while the direct financial implications were given a slightly lower priority.

According to the information provided by the accounting department, purchasing costs were 1000 VND/kWh of electric energy, 3400 VND/kg of fuel oil and 3500 VND/m^3 of freshwater (VND 20,000 equalled about € 1 at the time the case study was conducted). Fig. 5 presents a Sankey diagram of purchasing costs and aggregated costs. The unit price for chilling and compressed air was assumed to be the same as for electric energy.

Fig. 5 depicts the total energy and water costs, summing up to roughly VND 500 million (€ 25,000) per month or VND 6 billion (€ 300,000) per year. This makes up 'mere' 4% of total sales and had therefore not been of highest importance for decision making in the past. It should be noted though that by far the largest portion of production costs cannot be affected by management action. For

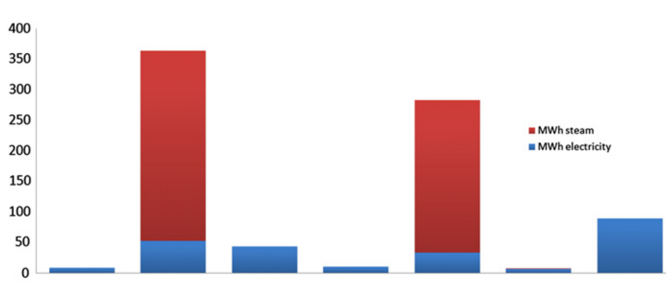

Fig. 3. Sai Gon Beer energy breakdown.

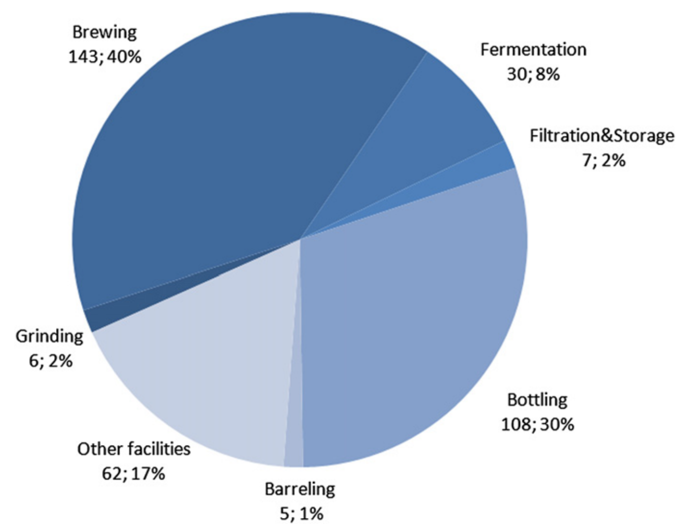

Fig. 4. Sai Gon Beer GWC breakdown (tonnes of CO_2-equivalent; % of total).

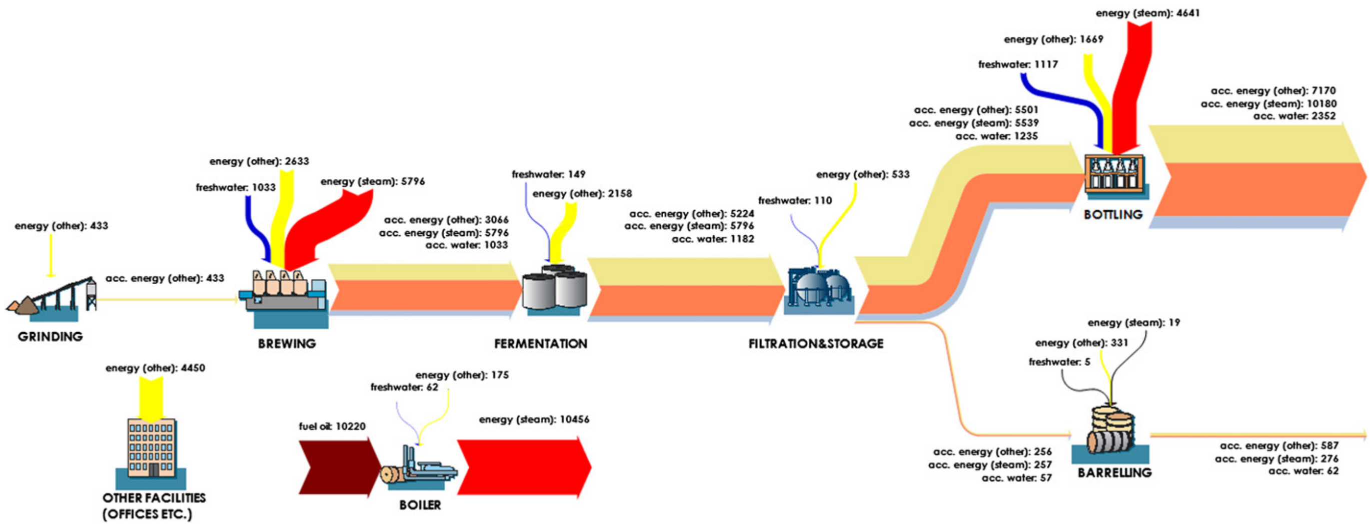

Fig. 5. Sai Gon Beer energy and water costs in € (monthly average).

instance, the options for reducing raw material purchase costs are very limited as solid waste and other by-products have already been reduced to a minimum (cp. Fig. 2).

The relevance of energy and water costs can be further highlighted by comparing them with labour costs. In rough terms, the total of monthly energy and water costs equals the monthly labour costs of 100 full time employees, half of *Sai Gon Beer*'s total work force.

4.3. Analysing CP potentials

Sai Gon Beer's production manager was alarmed by benchmark figures of other breweries. For instance, Jever, a medium-sized Germany brewery reported its relative energy and water consumption in its 2004 environmental report (Jever, 2004, p. 17). Fig. 6 compares these indicators to Sai Gon Beer's indicators derived from Fig. 2. This benchmark revealed that the demand for electric energy and water per hl of beer was about twice the demand of the German brewery. Due to the differences in climate (tropical vs. moderate) and technology this comparison with the German brewery is not necessarily a reliable benchmark, but nevertheless serves as a first orientation.

The MEFA results astonished the company's manager in another respect, too. The management had not expected the bottling step to be the major consumer of freshwater (cp. Fig. 2) and the second largest consumer of energy (cp. Fig. 3). Once known, an explanation for the high energy and water demand in this step was found: bottling includes the washing of returned bottles, which takes place in several steps using different water temperatures and detergents. The heating of water for washing consumes a huge amount of thermal energy and the water demand for washing turned out to be crucial, too. The benchmark in Fig. 6, which includes indicators for *Sai Gon Beer* and excludes the bottling step, highlights the relevance of this step for the overall energy and water efficiency. Water and energy efficiency are the relevant categories of eco-efficiency for *Sai Gon Beer* (for a general introduction to accounting for eco-efficiency see e.g. Schaltegger, 2002). Calculating these KPIs supports the management in focussing on simultaneous reductions of costs as well as water and energy consumption. In terms of electric energy, *Sai Gon Beer* remains behind the benchmark even if the bottling step is excluded.

Beside bottle washing, heat losses were identified as important energy consumption drivers. Given the high ambient temperatures of a sub-tropical setting, cooling processes and storage of cooled beer require special attention. The chilling demand of brewing, fermentation, filtration and storage accounts for almost 40% of the total electricity consumption (cp. Fig. 2). Another third of the total electricity consumption is driven by office and production buildings

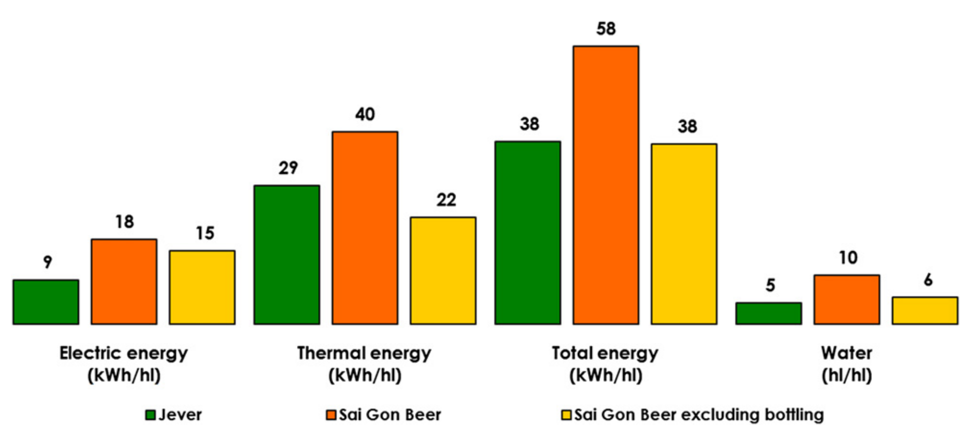

Fig. 6. Energy and water benchmark.

as well as other overhead electricity demand (Fig. 5), most of it resulting from air conditioning. Thus, as a substantial difference to the German beer brewery *Jever*, two-thirds of the total electricity consumption resulted from the provision of cooling energy.

Including energy and water costs into the EMA assessment supports the findings of the previously applied MEFA. Brewing and bottling are the most intensive production steps in terms of energy and water costs. Yet, reducing overall costs requires that the efficiency of these production steps and the steam supply is improved. Thus, as a next step, the air compressors and chilling units of *Sai Gon Beer* were analysed in detail to identify further CP improvement potentials.

The material and energy flow analysis including energy and water costs allows for comparing bottled and draught beer. Table 2 is derived from Figs. 2, 4, and 5 and highlights the environmental advantage of draught beer in comparison with bottled beer. The different energy sources explain the fact that energy and water costs of draught beer are nevertheless not much lower than those of bottled beer. Bottled beer requires comparably more thermal energy (steam) per hl while draught beer consumes greater quantities of electric energy, which is more expensive. In any case, comparison supports the conclusion of an Italian LCA study on lager beer: "From the previous analysis it turned out that the most effective actions to reduce the environmental burdens of the beer life cycles have to be promoted in the consumption phase, preferring draught beer to bottled one […]" (Cordella et al., 2008, p. 138).

4.4. Identifying CP improvement options

Based on the information obtained with the material and energy flow assessment, several CP improvement options were discussed and presented to *Sai Gon Beer*'s top management:

- The assessment revealed that a *cascade water recycling system* could be installed to reduce the water and energy consumption in bottling. For each of the four separate washing steps, freshwater had to be drawn from the tap, heated up with steam or electric energy, and discharged to the wastewater plant. A cascade system would only use freshwater for the final washing step and reuse the lightly polluted wastewater of this step as water input to the second last washing step. The wastewater from that second last washing step would serve as input for the third last step and so on. Such a cascade system would reduce freshwater, wastewater and steam demand substantially.
- A large energy saving potential was identified in the proper ins*ulation of pipes and tanks*, in particular where large temperature differences exist. For instance, several large beer tanks were situated outside in the tropical atmosphere and exposed to direct sunlight, while the beer inside these tanks had to be kept at a temperature below 2 °C. Installing a sun shades over these tanks and improving the tank insulation were calculated to be profitable and energy saving.
- The bulk of the energy consumption was caused by auxiliary processes, in particular the oil-fired boiler, air compressors, and the chilling devices. As a consequence, the efficiency of these processes was examined closely, including one-off measurements. The boiler, for instance, could use *exhaust heat for preheating of water* instead of using electric energy. Furthermore, the water needed for the steam generation could be *preheated by solar power*, e.g. by simply using a black hose on the roof of the production facility.
- The aggregated EMA information showed that office buildings consumed a considerable amount of energy. Thus, the use of *heat exchangers* was evaluated for several processes in the brewing step and could also be used to reduce the loss of thermal energy of air conditioners by using the cool exhaust air leaving the office and production buildings to pre-cool the incoming air.
- The results of the EMA based analysis of CP potentials showed that the *environmental management system* could be improved by including more *ambitious and specific indicator based targets* on energy and water consumption. Targets such as the annual 0.5% reduction of energy consumption per unit of product were replaced by more ambitious ones.

Table 2
Comparison of the relative resource consumption of bottled and draught beer at *Sai Gon Beer.*

Product	CO_2-eq. (kg/hl)	Water (hl/hl)	Costs (VND/hl)	Total energy (kWh/hl)
Bottled beer	8.16	4.80	29,600	21.23
Draught beer	7.89	0.48	29,400	12.08
Ratio bottled to draught	3.4%	907.4%	0.9%	75.8%

As the top management was pleased with the recommendations it got interested in establishing EMA on a more regular basis to improve measurements. It furthermore considered including EMA as an assessment tool in the planning process of its new production plant. Based on these results, *Sai Gon Beer* commissioned a Japanese company to conduct a feasibility study for energy efficiency measures at its new plant. The commissioned company recommended the establishment of a so-called 'total energy management system' in combination with Cleaner Development Mechanism measures.

5. Towards more informed decisions for cleaner production

The take-home message of this case study on Sai Gon Beer is three-fold. Firstly, the case study provides an example that increasingly recognized voluntary corporate initiatives such as CP (Lozano, 2012) can be achieved more efficiently on the basis of relevant and robust information. EMA and the EMA framework can help to identify and create this kind of information. Secondly, the case study illustrates that EMA is understood, applicable and suitable to support CP also in a typical setting of a developing country. Thirdly and most importantly, very few case studies on EMA for CP exist for developing countries, compared to a relatively large number of case studies in industrialized countries. This imbalance might trick managers to believe that CP and EMA would be beneficial for industrialized countries only. However, as the case study illustrates, actually the opposite is true. The proportion of material and energy costs compared to labour cost as part of the total production costs is relatively much higher in developing countries than in industrialised countries (Hasanbeigi et al., 2012). The application of EMA for CP thus reveals much higher relative cost saving potentials in developing economies.

As the above case study shows, by using the EMA framework, managers were able to identify their information needs and choose the most powerful environmental information management tools in a systematic manner. More importantly, these tools not only serve to use information for various decision-making situations but also support the systematic identification and retrieval of such information.

This case study approach can be seen as a guiding example for introducing environmental data collection by firstly considering the decision situation on basis of the EMA framework. Once the most adequate EMA tools have been identified, applied and valuable information has been created, management may be motivated to establish EMA on a more regular basis and to broaden the application of different EMA tools. For example *Sai Gon Beer* established a regular collection of environmental data (boxes 3 and 1 in Fig. 1) and applied an environmental investment appraisal and planning (boxes 14 and 16 in Fig. 1) for planning its new production plant.

The case study may be particularly revealing as for the promotion of CP in a company the most relevant research questions are 'how' and 'why' rather than requiring broad statistical analysis (cp. Eisenhardt, 1989; Yin, 2009). This is why this case study illuminates the application and implementation process of EMA as a tool for CP. The first units of analysis are the company specific management decision situations, which can vary substantially, depending on the company's physical context (e.g. tropical vs. moderate climate), the type of management activity (investment, operational production activity, *ex post* assessment of a project, etc.), the management level (top management, middle management, etc.), the department in charge (accounting, finance, production, environment, etc.), the time frame, and the risk attitude.

This case study is based on *Sai Gon Beer*'s written records, personal onsite-inspection, and oral information provided by the environmental, production and accounting departments. Data obtained was compared with figures available in several publications on brewing referenced throughout this study. Based on these publications the order of magnitude and the general direction of the results derived from the data available can be considered as reliable. However, the overall completeness and data quality of the EMA application can only be classified as medium. In particular, the breakdown of material and energy flows to production and supply processes is based on qualified estimates and computations by production managers and engineers. Actual measurements, as planned by management after they realised the CP potential, could be carried out to improve the reliability of information.

Applying EMA at *Sai Gon Beer* has helped the production, environmental and accounting departments to identify drivers of environmental performance and related costs. The management was surprised to find out that certain steps in the production process such as bottle filling and bottle washing were amongst the major drivers of water and energy consumption and thus environmentally induced costs. As the existing environmental management system did not break down the physical inputs and outputs to single production steps and supply processes, this fact had been overlooked prior to conducting the EMA analysis. A cascade water recycling system and several others environmental improvements were identified which would easily exceed the environmental goals of *Sai Gon Beer* stated in its environmental reports. Thus, the case study shows that the introduction of EMA can create benefits for environmental management systems by providing a detailed information basis for target setting, planning of improvement measures, and performance monitoring.

The application of EMA at *Sai Gon Beer* comprised basic MEFA and the breakdown of related energy and water costs. Albeit elementary, the analysis led to the identification of several improvement options and made the top management rethink its environmental targets and establish EMA on a more regular basis. This case study thus confirms the experiences of Jasch (2006, 2009) and Onishi et al. (2008) in introducing MEFA and highlights the relevance of EMA also for beer brewing in developing countries. EMA shows particular importance of the MEFA approach, which enables managers and engineers to break down relevant physical information to separate production steps and supply processes. EMA can help to meet the accounting criteria of materiality, i.e. it helps to focus on 'hot-spots' – those steps and processes with the highest potential for improvement and the greatest impact on overall (environmental) performance. This can be done in four major steps. The initial step (i) consists of inspecting material and energy flows and is followed by (ii) identifying the decision situation when investigating material and energy flows. Based on the relevant decision situation identified, (iii) a corresponding information management tool from the EMA framework can be chosen and applied to obtain the relevant information to (iv) support informed decisions when applying CP. This structured information acquisition process supports the implementation of CP in a systematic manner.

The case study highlights the importance of considering both, production processes and auxiliary processes. Most of the energy required at *Sai Gon Beer* is related to steam production, a central boiler, chilling and refrigerating units, as well as compressors.

Overall, the application of EMA at *Sai Gon Beer* supports the findings of earlier studies dealing with beer production in developed countries and the beer life cycle: "At the process level, improving the energy and material use efficiency of energy intensive equipment could enhance efficiency of production and processing. There is a clear need to expand the focus of the past and existing cleaner production efforts, which were mainly focussing on solid waste and dust control towards enhancing energy and resource use efficiency" (Narayanaswamy et al., 2005, pp. 15–16). Given the strong growth rates of the food industry and beer production in developing countries the more wide-spread application of EMA could foster CP where it is needed most.

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