Indicators for Sustainable Development in the Belgian industry

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Goals

This paper summarizes our work concerning the measurement and reporting of environmental performance of the Belgian industry, the food-processing industry in particular.

Although focusing primarily on environmental performance measurement and reporting, this paper recognizes that some researchers are also addressing measurement and reporting of the broader dimensions of sustainable development, in a few cases even trying to integrate reporting on the environmental, social and economic aspects of industrial performance.

In the past relatively little attention was directed to examining the indicators that industrial firms use to measure environmental performance. Our initial goal was to identify a set of environmental performance indicators that would find broad utility across industries, improving their ability to assess environmental performance, and assist in the setting of both national and industrial environmental goals. However, in an attempt to provide more in-depth analysis rather than a general investigation, we decided to concentrate our efforts on just one (broad) industrial sector, the food-processing industry, and on one particular sector within that industry, namely breweries.

The specific goals of our study were:

- To examine existing experience in measuring progress in environmental performance;

- To identify factors that will improve industrial environmental performance;

- To assess the shortcomings of existing methods of measuring industrial environmental performance;

- To recommend a set of industrial environmental performance indicators.

Our study aimed to be an *industry-centered* analysis, focusing on a set of key areas of performance.

Activities

The project consisted of 3 phases.

Phase 1: Analysis of the environmental pressures caused by the Belgian industry and the formulation of “Status indicators”

It was decided to concentrate on a thorough case study of one sector of the Belgian industry, namely ‘breweries’. A detailed sector study was carried out, with a focus on:

- delimiting the sector and defining its relationships with other sectors;

- defining the products, its applications and its physical, chemical and environmental characteristics;

- describing the strategies and trends in demand and production, foreign trade, market structure, investements and employment;

- describing production processes (technologies), inputs (consumption of raw materials, water and energy) and unwanted outputs (waste, emisssions to air and water, noise, …).

Each step in the process was regarded as a ‘black box’. In that way, the inputs and outputs could clearly be identified for each part of the process. This simplified the task of evaluating the environmental pressures caused by each step in the process, and thus of creating the so-called ‘status indicators’ at that level.

The necessary data were collected from existing databases, literature, federations and individual firms. An extensive survey was carried out.

Phase 2: Formulation of “Response indicators”

After having divided the production processes of the brewery sector into several important process steps, environmental pressures and possible meausures to eliminate or decrease these pressures were formulated. The most problematic process steps were identified and further investigated.

This led to the formulation of so-called ‘response indicators’. Most attention was given to measures related to pollution prevention. The detailed study of the process steps revealed all the important variables and parameters determining the environmental pressures exerted by breweries. Re-adjusting these variables and parameters could possibly lead to serious reductions of inputs (raw materials, water, energy), and unwanted outputs (solid waste, emissions to air and water, energy waste, ..). Measures concerning re-use, recycling and disposal (incineration, deposits), were also takken into account.

The response indicators were divided in measures representing a reference state of low effort (i.e. simple and short-term options) and a reference state of maximum effort (i.e. long-term options for process and product innovation).

An attempt was made to extend the results of the case study to the whole food-processing sector of the Belgian industry.

Phase 3: Evolution of progress towards sustainable development

The federal authorities could use the developed indicators as a tool to measure the environmental pressures caused by the breweries or other sectors in the food-processing industry, and the progress made by that particular sector towards sustainable development.

Results

Profile of the Belgian breweries

At present there are some 112 breweries in Belgium (down from 3.223 in 1990). Their total production output in the year 2000 amounted to 14.733.779 hl per year. Production has remained steady since 1980. The decline in domestic consumption has been adequately offset by exports, which have more than doubled since 1960. Belgian beer exports currently account for more than 37 % of total production.

A description of the brewing process.

The brewing proces consists of the following process steps or ‘unit operations’:

- Malting. Barley is steeped in water for two days, then transferred to large shallow boxes where it is allowed to germinate or sprout. As the barley begins to grow, biochemical changes occur within the grains and enzymes are formed and activated. Once sufficient enzyme levels are attained, the sprouted barley, now called malt, is kilned. By changing the temperature and humidity levels in the kiln, the flavor and color of the malt can be specified;

- The mill. Malted barley and other specialty malts are lightly crushed in a roller mill, keeping the husk mostly intact, but exposing the starchy endosperm;

- The grist case. The crushed malt, now called grist, is moved by conveyors to the grist case, where each batch is weighed out;

- The hot liquor tank. Hot water from the hot liquor tank is mixed with the grist in the steel's masher, a blending device located between the grist case and mash/lauter tun;

- The mash / lauter tun. The roughly mixed grist and hot water, now called mash, are thoroughly mixed in the mash/lauter tun, and allowed to rest for 90 minutes. During this time, naturally occurring enzymes from the grain become activated and convert the grain's starch into fermentable and non-fermentable sugars. This process is called conversion. After conversion is complete, lautering begins, or run-off to the kettle. More hot water is sprayed on top of the mash, to rinse the grain and extract all of the sweet liquid called wort;

- The brew kettle. Once the brew kettle is full of sweet wort, boiling begins. Hops are added at different times during the boil, to impart bitterness, character, and aroma;

- The whirlpool. After boiling for 90 minutes, the hopped wort is sent to the whirlpool, which clarifies the wort by settling out the hops and the trub (proteins which coagulate during the boil;

- The hop back. From the whirlpool, the wort is strained through more fresh hops, in the hop back. This gives the beers a fine fresh hop nose (aroma);

- The heat exchanger. The wort passes through a heat exchanger, to bring its temperature down from 200+°F to 70°F in a matter of seconds. After the wort is cooled, yeast is added to it, on its way to the fermenter;

- The fermenter. In the fermenter, the yeast metabolizes the fermentable sugars, producing ethanol (the alcohol) and carbon dioxide (the bubbles). The fermentation and maturation process takes about two weeks;

- The filter. After fermentation, the beer is filtered through several layers of diatomaceous earth, to remove any remaining trub, hops, and yeast, or filtration is accomplished with a D.E. filter, which clarifies the beer by passing it over microscopic siliceous particles;

- The bright beer tanks. In the bright beer tanks, the correct CO_2 level is reached and the beer is allowed to condition until packaging;

- Packaging. The beer is packaged in any one of a number of containers, including 12-ounce bottles, 64-ounce growlers, and kegs (in 5, 7.5, and 15.5 gallon sizes) to provide maximum flexibility for the customer.

Once the process steps had been identified and described, relevant information was gathered, more in particular on water usage, wastewater output and waste production and recovery. The volume and composition of discharges can vary considerably with the type of beer produced.

Key status indicators for the breweries and the food-processing industry in general

- Raw Materials. For the most part, breweries or food-processing facilities in general, are located close to their agricultural source. In the food-processing industries, one chief raw material usually makes up the largest percentage of the final food product's composition. The beverages industry, including breweries, are a notable exception to this rule;

- Water. Traditionally, breweries are large users of water. In the food-processing industries water is mostly used as an ingredient, but also as an initial and intermediate cleaning source, an efficient transportation conveyor of raw materials, and a principal agent used in sanitizing plant machinery and areas. Although water use will always be a part of breweries, it is a principal target for pollution prevention and source reduction practices. The main areas of potential reduction being considered by the entire food-processing industry are water used in conveying materials, plant cleanup, or other noningredient uses;

- Energy Use. Compared to other industries, such as the pulp and paper industry, the food processing industries are not considered particularly energy-intensive. Facilities usually require electrical power, supplied by local utilities, to run the machinery. Fossil fuel use is relatively low. In most cases natural gas is used to operate the boilers. Breweries however are an exception to this rule;

- Air Emissions. Air emissions are not a major concern for the food-processing industry, with the exception of breweries. Most operations typically utilize electric power and rarely emit harmful compounds to the environment during normal production operations. Air emissions from biological treatment processes have become an area of concern, but a relatively minor one compared to wastewater issues;

- Wastewater. Primary issues of concern are biochemical oxygen demand (BOD), total suspended solids (TSS), and excessive nutrient loading, namely nitrogen and phosphorus compounds. The wastewater of breweries can be characterized as nontoxic, because it contains few hazardous and persistent compounds, with the possible exception of some toxic cleaning products. The wastewater of the fermentation processes is high in BOD. The overall wastewater volume of breweries is high compared to other food-processing sectors;

- Solid Waste. Primary issues of concern include both organic and packaging waste. Organic waste results from processing operations, i.e. spent grains and materials used in the fermentation process. Inorganic waste typically includes excessive packaging items, that is, plastic, glass, and metal. Organic wastes are finding ever-increasing markets for resale, and companies are slowly switching to more biodegradable and recyclable products for packaging. Excessive packaging has been reduced and recyclable products such as aluminum, glass, and high density polyethylene (HDPE) are being used where applicable.

The following list suggests a number of input-ouput environmental data of all Belgian breweries, to be used as status indicators for this particular industrial sector. The environmental issues of most importance to the breweries have been considered in two broad categories:

- Process inputs (resource consumption / conservation);

- Process outputs (principally solid waste, water pollution and air pollution)

Table 1: status indicators of inputs and (wanted) outputs for the breweries

Indicator	Total value: unit	Specific value: unit
Raw materials		
Barley	t/a	kg/hl
Malt	t/a	kg/hl
Raw fruit	t/a	kg/hl
Hop	t/a	kg/hl
Water		
Fresh water	mio m^3/a	m^3/hl
Process water	mio m^3/a	m^3/hl
Containers, packages		
	t/a	kg/hl
Energy		
Heat	GWh/a	kWh/hl
Electricity	GWh/a	kWh/hl
Finished product to be sold		
Malt	t/a	
Beer	hl/a	

Table 2: status indicators of unwanted outputs for the breweries

Indicator	Total value: unit	Specific value: unit
Recoverable materials		
Draff	t/a	kg/hl
Dry draff	t/a	kg/hl
Malt culms / powder	t/a	kg/hl
Spent grains	t/a	kg/hl
Bottom yeast	t/a	kg/hl
Recoverable wastes		
Cardboard	t/a	kg/hl
Waste paper	t/a	kg/hl
Waste labels	t/a	kg/hl
Pallets	t/a	kg/hl
Waste glass	t/a	kg/hl
Waste cases	t/a	kg/hl
Waste cans	t/a	kg/hl
Waste metals	t/a	kg/hl
Waste crown caps	t/a	kg/hl
Waste plastics	t/a	kg/hl
Kieselguhr	t/a	kg/hl
Others	t/a	kg/hl
Solid waste produced		
Hazardous wastes	t/a	kg/hl
Garbage	t/a	kg/hl
Other (filtration residue,…)	t/a	kg/hl
Waste water		
Volume	mio m^3/a	m^3/hl
COD	t/a	kg/hl
BOD	t/a	kg/hl
NH_4-N	t/a	kg/hl
tot-P	t/a	kg/hl
Atmospheric emissions		
CO_2-emissions	kton/a	kg/hl
SO_2-emissions	ton/a	kg/hl
NO_x-emissions	ton/a	kg/hl
Noise		

Noise originates from the filling plants, trucks en dust exhaust fans in the maling-house. Data are seldomly available.

It would be desirable to fully develop these indicators of industry performance regarding the key issues within each of these categories. Unfortunately, there is an insurmountable scarcity of information about the environmental performance of the breweries upon which these indicators must be based.

Response indicators

Clean technology developments

Wastewater generation is the breweries' or most other food-processing firms' biggest area of concern. Therefore, most research on clean technologies focuses on the source reduction, recycling, reuse, and treatment of wastewater. Clean technologies are defined as "manufacturing processes or product technologies that reduce pollution or waste, energy use, or material use in comparison to the technologies that they replace."

Common source reduction methods employed at most breweries or other food processors include:

- improving good housekeeping practices A number of simple cost-effective means of achieving source reduction include installing automatic shut-off valves, using low-flow or air-injected faucets / spray cleaners, safety mechanisms to prevent overfilling, etc.;

- making process modifications. Process automation allows the user to improve efficiency, control the process of raw material inputs, and control the amount of wastes generated. Sensors can be used to control process temperature, humidity, pH, flow rates, and contamination levels. Automation reduces the chance of human error in manufacturing processes, it improves speed and accuracy in measuring process variables, and it reduces labor costs. Progressive automatization however can lead to rising consumption of electric energy;

- substituting more environmentally friendly raw materials. Examples include the use of biodegradable cleaning agents, or of peroxyacids instead of chlorine-containing cleaning agents and disinfectants, to avoid generation of hazardous chlorinated substances;

- segregating waste streams. Pretreatment opportunities look to minimize the loss of raw materials to the food-processing waste streams. This so-called "zero-discharge strategy" requires large capital expenditures and customized treatment solutions, which are difficult to find "off-the-shelf" because of the uniqueness of the various food-processing operations. The "zero emissions" strategy on the other hand relies on a network of companies utilizing each other's waste streams. This strategy is an economically more efficient system, because it does not require the waste products to be fully treated. Although effluent quantities are decreased, material mass balances still dictate that process residuals such as sludges will require management and possibly off-site disposal.

Advanced wastewater treatment practices

Advanced wastewater treatment is defined as any treatment beyond biological (or secondary) treatment. These treatment practices are employed to target specific discharge constituents that are of concern. Typically, suspended or dissolved solids, nitrogen, and phosphorus are removed in advanced wastewater treatment.

Some technologies being used in advanced treatment of food-processing wastewater are:

- Membrane applications. Membrane applications focus on separating water from contaminants, using semipermeable membranes and applied pressure differentials.

Microfiltration, ultrafiltration (UF), and reverse osmosis (RO) are the current membrane systems used commercially. The filtering capabilities of each, i.e. the ability to filter based on contaminant particle size, decreases respectively. Membrane applications can be less energy intensive than evaporation and distillation operations, and thay take up less space. Membrane technology does not produce a sludge disposal problem (unlike chemical precipitation), but it does produce a concentrated brine solution;

- Ozonation and UV disinfection. Chlorination to disinfect wastewater is being heavily criticized due to chlorination byproducts and toxicity concerns that residual chlorine pose to aquatic life. Ozone disinfection and UV disinfection are the two principal means of disinfecting wastewater without using chlorination. Ozonation leaves no residual in the treated wastewater, and it does not produce the same amount of disinfection byproducts that chlorination produces. UV disinfection is even more environmentally friendly, but requires more space and cleaner wastewater to be effective. Both technologies require high capital and operating costs;

- Charge seperation. Charge separation involves separating uncharged water molecules and charged contaminants, such as nitrogen compounds, and phosphates (i.e. NH_4^+, NO_2^-, NO_3^-, and PO_4^{-3}). Ion exchange is widely used to filter wastewater through cationic and anionic resins to remove the wastewater's charged ions of concern. Ion exchange replaces the waste particles with a donor ion from the resin. Ion exchange does not produce a chemical sludge, it protects the water quality of the receiving waters, and it decreases the nutrient-loading problems that cause eutrophication in receiving waters;

- Other technologies. Other separation practices include using centrifugal and gravity mechanisms to separate and remove contaminants from a wastewater. Problems with these methods include capital costs to modify current treatment processes, and increased operational energy costs;

Improved packaging

Food-processing manufacturers have to re-evaluate their use of packaging, because excessive packaging has contributed to an overabundance of solid waste, and a fast-growing dilemma of what to do with it.

Packaging changes at breweries or other food manufacturers include:

- the use of plastic liners in corrugated boxes;

- the use of high density polyethylene (HDPE) plastic totes;

- the substitution of foam food-packaging containers for ones made from materials free of chlorofluorocarbons;

- the use of recyclable products such as aluminum, glass, and HDPE where applicable.

Benefits of changing packaging are:

- decreasing costs in some cases (but in most cases the cost is the same or even slightly higher);

- improving the public relations image and gaining an advantage over the competition, throught advertising packaging as more environmentally friendly;

- decreasing the ultimate solid waste disposal and associated costs ('disposal charges').

Reduction of energy consumption

The recycling of heat through heat exchangers should be achieved. Further possibilities to regain energy (e.g. generation of biogas by anaerobic treatment of highly polluted waste waters or sludges) should be evaluated.

Reduction of emissions into the atmosphere

To reduce the emissions of substances into the air the following measures can to be taken into account:

- capsulation of devices and installations;

- appropriate storage of substances;

- desucking of waste gas;

- purification of waste gas.

Recommendations

To enhance the development and use of industrial environmental indicators, the federal authorities should take the following actions:

- establish *quantitative* goals, both at the national and at the firm level, and strenghten the role of the federal authorities in setting and reporting progress toward attaining these national environmental goals;

- develop improved methods of ranking, categorizing and prioritizing the relative impact of industrial environmental loads. This requires moving from the measurement of environmental *loads* (resource use, water emissions, air emissions, …) to the measurement of environmental *impacts* (human health impacts, ecosystem impacts, …);

- establish consistent, standardized industrial environmental performance indicators, allowing for benchmarking across industries, and promoting these standardized indicators in international forums;

- promote the development and use of industrial environmental performance indicators, and transfer knowledge on best practices in industrial environmental performance measurement across industries and sectors, particularly to small and medium-sized enterprises;

- conduct research on methods of integrating socioeconomic criteria into sustainability measures, and on furthering the understanding of the implications of long-term industrial activity on the environment, including issues such as materials flow and energy use.

Industrial indicators for sustainable development can provide a tool for influencing the decision making, both at the government and at the manufacturer level.

Selection of references

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