Management and Production Engineering Review
Volume 11 • Number 4 • December 2020 • pp. 129–137
DOI: 10.24425/mper.2020.136127

ECOLOGICAL PROJECTS FROM THE PERSPECTIVE OF ECONOMIC AND ENVIRONMENTAL IMPACTS – A CASE STUDY OF GALVANIC CELL MANUFACTURER

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Received: 5 November 2018
Accepted: 15 December 2020

Abstract
Sustainable development refers to the development of a business in such a way that future generations will be able to satisfy the same needs. This article describes how sustainable development can be measured by economic performance and a positive impact on the natural environment. A general indicator of a company's environmental impact is presented in the article. It can be determined, on the one hand, by a company's environmental impact, and on the other hand, by savings in the use of natural resources, which is associated with savings in a financial sense. Therefore, it can be used to analyze the progress of sustainability in terms of environmental and economic performance. The case study provides an example of how emissions and energy factors can be analyzed to form a synthetic indicator and create a general indicator.

Keywords
Sustainable development, environmental impact, auxiliary processes, case study.

Introduction

A considerable amount of literature has been published on the sustainable development, especially since it began to grow in importance in terms of performance benefits [1]. Growing awareness of environmental issues and increasing pressure from stakeholders has forced organizations to invest in environmentally friendly processes and products [2]. Various conceptual frameworks and corporate initiatives have been put forward to manage sustainability issues from various perspectives [3]. Where in the past, solid economic performance was supposed to guarantee the success of a company, today's economy is increasingly driven by the so-called triple bottom line, where economic results are balanced by minimizing the ecological footprint and taking social aspects into account [4].

A number of definitions of sustainable development have appeared. In general, sustainable development refers to the development of a company in such a way that future generations will be able to satisfy the same needs. With increased environmental awareness in the 1970s and '80s, a focus on sustainable development began. In 1987, the Brundtland report helped highlight that development should include the satisfaction of both present and future needs of people without overexploitation of the natural environment and its resources [5, 6]. Around this time, severe pollution and environmental accidents increased due to the negligence and passivity of companies with regard to sustainability and social and environmental issues. This increase in environmental awareness pushed companies towards sustainable business practices [7]. Companies began to pay attention to less traditional factors in business, and to

address the environmental, social and economic impact of sustainability on their business [8, 9]. Companies recognized that focusing solely on economic growth would be harmful to their business and future generations [10–12].

This article describes how sustainable development can be measured by economic performance and a positive impact on the natural environment. Economic performance is measured in terms of profits, while environmental performance is measured in terms of factors such as resource consumption, pollution and waste created, and an overall carbon footprint [8, 13, 14]. It is necessary to choose the most appropriate framework with a set of indicators that best describe the suitability of the organization's performance [15].

Methodology

The paper uses a case study approach with a focus on Galvanic Cell Manufacturer. Therefore, a case study approach has been used in this study to provide insights into the phenomenon under investigation. In this study a single case study is used. While several studies generally provide a stronger basis for theory building [16], it has been shown that single case studies can provide a richer description of the existence of a phenomenon [17].

Environmental threats from industry affect various elements, such as soil, water, landscape and others [18]. Companies can have a negative impacts on the environment through production and auxiliary processes, including the use of natural resources and the production of byproducts. As auxiliary services are always present in companies, and their complete elimination is not possible, attention should also be paid to ways of optimizing the services that occur. They are wasteful in themselves, but wastefulness also generates unnecessary expenditure that has a negative impact on a company's economic performance. It should be stressed that the same resources that are used for the main activities are also needed and used for the supporting processes. Using too many resources for non-profit processes is wasteful. If these types of processes do not add value to a company, they should be eliminated (if they are not necessary) or optimized (if they are necessary). To decide which activities should be excluded from identification, a mapping of processes should be done to plan the optimization of non-profit but necessary processes, and an identification of waste should be conducted [19–21]. The areas of output of production and auxiliary processes shown in Fig. 1, are the input

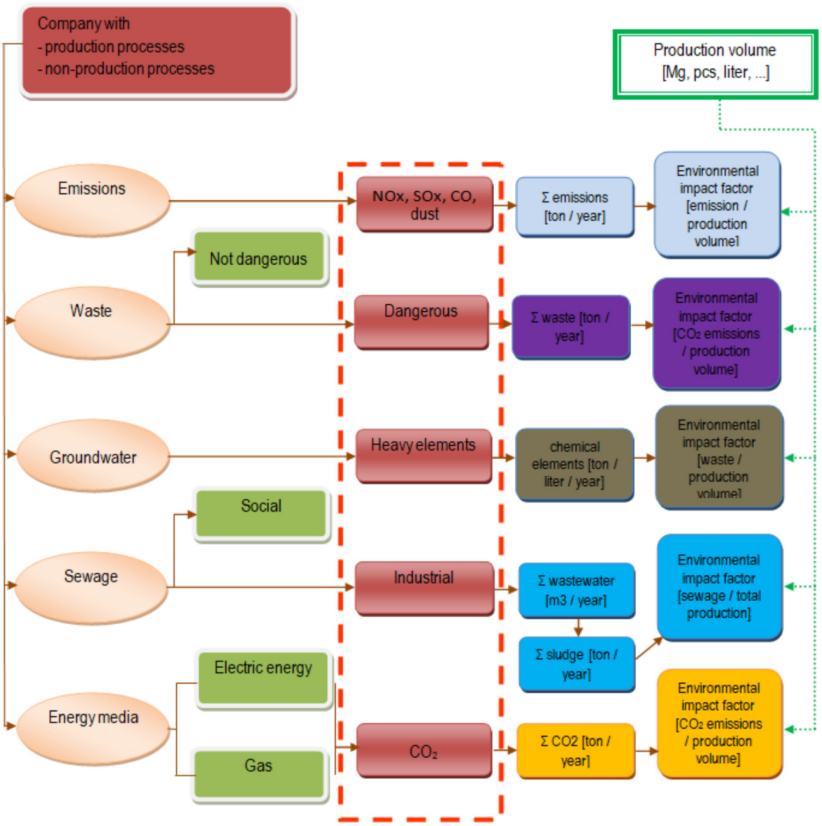

Fig. 1. A synthetic indicator of a company's environmental impact.

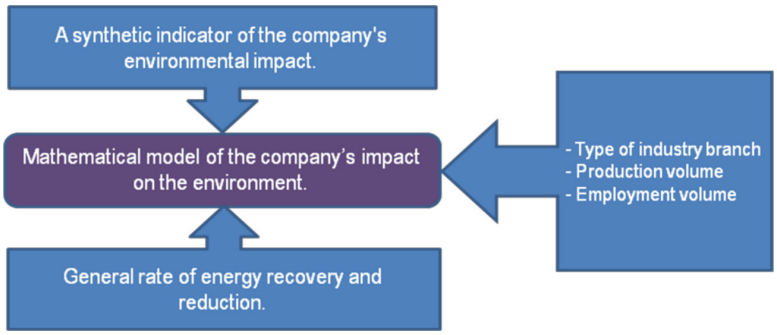

Fig. 2. A general indicator of a company's environmental impact (source: own work).

areas for further consideration and the creation of a generalized indicator of a company's environmental impact. The input areas consist of five groups:

- emissions;
- waste Management;
- impact on groundwater;
- sewage;
- electricity and gas consumption.

After identifying and evaluating environmental aspects, significant aspects of the environmental impact of companies have been identified (e.g. NOx, heavy elements, CO2) [22].

The environmental impact, however, is any change in the environment, both favorable and unfavorable, caused by the impact of a company in the areas presented, its products or services. The impact areas have been reduced to a common denominator (i.e. unit: tons/year) and related to production volume.

As a result of comparing the sum of the influencing factor in [tons/year] in correlation to the production volume in units adequate to the type of production [tons, pieces, liters, etc.], environmental impact coefficients were created. The impact coefficients are a sum component to create a generalized index of a company's environmental impact.

A general indicator (Fig. 2) of a company's environmental impact can be determined, on the one hand, by a company's environmental impact, and on the other hand, by savings in the use of natural resources, which is associated with savings in a financial sense. Therefore, it can be used to analyze the progress of sustainability in relation to environmental performance and economic performance [23–25].

Economic performance

A competitive advantage of economic performance can be achieved by performing important value chain activities at lower cost than competitors [21]. A rapidly changing business environment, strong competition, and requirements to minimize losses are some of the conditions in which organizations operate today [26, 27]. This has triggered organizations to continuously search for new ways to improve performance and gain a competitive advantage. One of the ways to help an organization achieve lower operational costs and better performance is waste elimination, which means, for example, economical use of natural resources and sufficient management of physical assets [28] especially in an asset-intensive industry [29]. Over the last two decades there has been a steady increase in demand for an effective physical asset management [30], especially to enhance sustainability performance [21]. Previous studies have used different methodological approaches to address economic performance of sustainability, such as regression-based study [31], Tobin's q [32], theoretical and conceptual study [33] etc. However, studies that would examine economic and wider sustainability performance are still justified by the inconclusive results of the existing literature.

Environmental performance

The high energy consumption of processes is an expenditure closely linked to asset management. It is estimated that manufacturing industries consume more than 75% of the total energy produced worldwide [18]. This is a significant cost factor borne by companies, and also has a negative impact on the natural environment, which is polluted by the energy industry through factors such as increased CO2 emissions, but also through other greenhouse gases, such as SO2, dust, and CO [18].

When analyzing a model company for energy consumption, the main sectors of energy consumption should be specified and the emission areas of emissions should be searched. For a correct and detailed analysis, all production and non-production processes should be considered. The main production pro-

cesses that add value to a company and generate operational profit should be specified and developed, as well as auxiliary processes that also have a significant impact on efficiency and the natural environment [34, 35].

If one focuses on the energy intensity mentioned above, it is possible to propose several solutions to improve the auxiliary processes, which are beneficial solutions from a financial and environmental point of view. The reduction of pollutant emissions into the environment is possible today by using unconventional energy sources. Water, wind energy and biomass account for the largest share of energy production, with the latter being used not only to generate electricity but also to produce thermal energy [36].

However, the ideal solution would be to reduce the energy consumption of the auxiliary process itself, which would bring measurable benefits for a company and the environment. It is therefore possible to use modernization of all equipment that consumes energy, for example by replacing light bulbs that light production halls with energy-saving bulbs. It is possible to limit the operation time of these devices to the necessary minimum, for example by inserting motion sensors that activate the mentioned lighting only when someone passes through a given area of the hall. There are many solutions and they are widely offered on the market, because awareness of the need for environmental protection has increased significantly in recent years among small and large companies [37, 38], and an example of such an effective implementation is provided in the case study.

Case study

This case study presents an example of how to analyze emissions and energy media factors that form a synthetic indicator (Fig. 3). The procedure started with analysis of electricity consumption in non-production processes in a chemical industry plant.

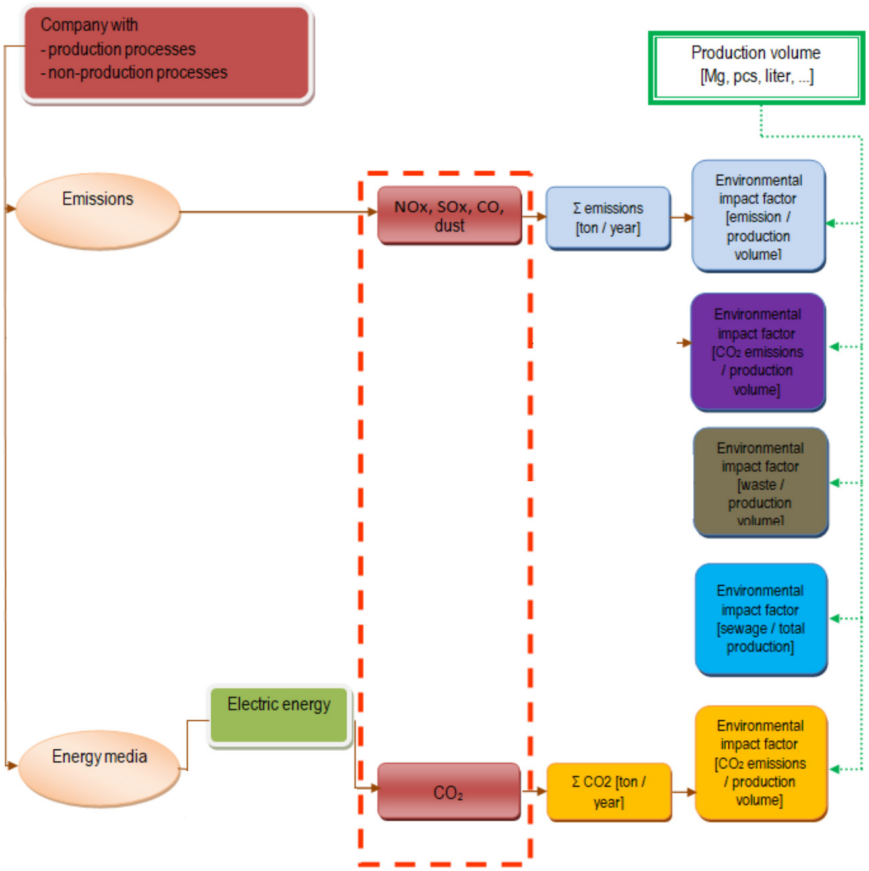

Fig. 3. A synthetic indicator of the company's environmental impact (source: own work).

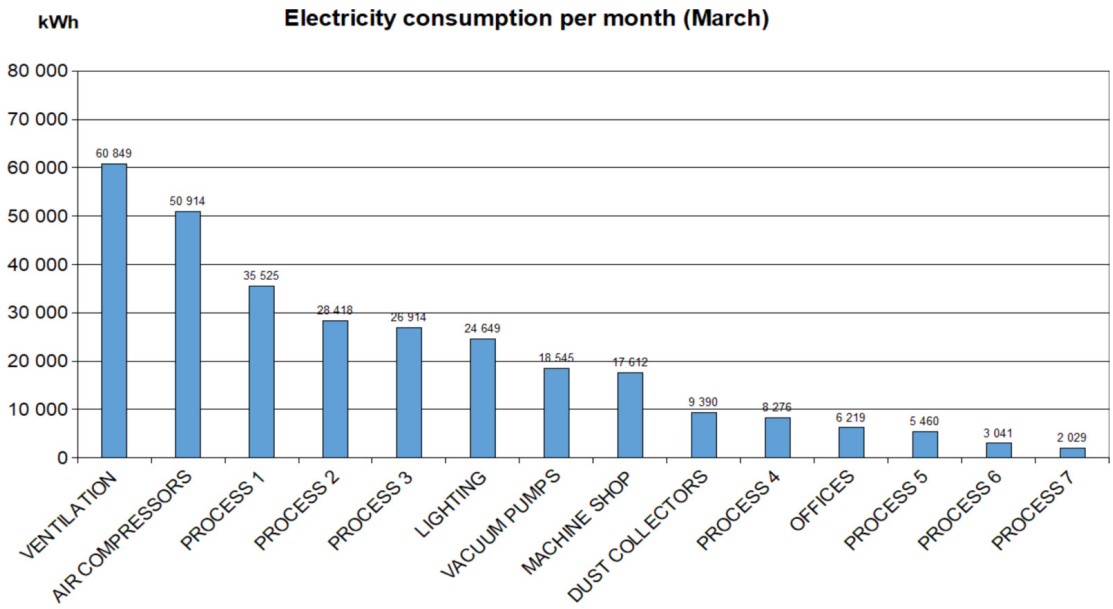

Fig. 4. Electricity consumption divided into production and non-production sectors (source: own work).

The company is medium-sized and belongs to a global company that cares about sustainable development. The plant manufactures galvanic cells used for everyday use. Galvanic cells are completely safe for the environment, they do not contain the heavy elements mercury, cadmium, or lead. Reduction of CO2 emissions by lowering electricity use is one of the plant's environmental policies.

The amount of energy consumption is illustrated in Figure 4. Analyzing the data presented in Fig. 4 of electricity consumption, which taxonomically depicts the most energy-intensive areas, we note that the first two items in terms of energy consumption in the model plant are occupied by non-production processes, which are ventilation and compressed air production (non-production processes in Fig. 4 are described, while production processes are described as PROCESS 1, 2, 3, ...).

The process of ventilation in workplaces is a process required by law, on technical conditions that should be met by buildings and their location. It is divided into two basic types: mechanical ventilation – forced ventilation, and gravitational ventilation – free. Due to the specificity of industrial plants and the task of ventilation, mechanical ventilation is most often used, which is implemented through ventilation units with supply and exhaust fans. Electric motors in the control panels are greatly energy-consuming and have powers that often reach up to 100 kW.

According to the data from Fig. 4, the process of reducing energy consumption began with the most energy-intensive area, which is mechanical ventilation. Finding a solution that is a compromise between costs incurred for energy, and costs incurred for investment, is a difficult process from the point of engineering solutions, and at the same time significant from the economic point of view – the return on investment. One of the first steps was to create a hybrid system, which was a combination of mechanical ventilation and gravity ventilation.

After analyzing the method of savings, the plant was invested in a mechanical and gravity ventilation system on selected units. Table 1 shows the motor power for the exemplary largest ventilation units that were implemented.

Table 1
Power of installed engines in air handling units.

AH 1	Supply air	75 kW
	Ventilation	55 kW
AH 2	Supply air	55 kW
	Ventilation	37 kW
AH 3	Supply air	37 kW
	Ventilation	15 kW

The system's operation algorithm is as follows:

- Electrical actuators connected to the weather unit are installed in the smoke exhaust dampers. If the temperature in the room of the production hall rises above the set temperature, and there is no rain, the smoke exhaust dampers are opened, which simultaneously act as exhaust ventilation.
- Exhaust air unit of the control panel – does not work.
- Supply air motor for the ventilation unit – it works.

Table 2
Electricity consumption and savings by air handling units before and after actions.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total [kWh]	Total CO2 [t]	Total [PLN]
Ventilation before implementation [kWh]	65000	66000	65000	68000	66000	68000	68000	68000	68000	66000	66000	68000	802000	531	320800
Ventilation after implementation [kWh]	65000	66000	65000	48000	40000	39000	66000	67000	25000	22000	66000	68000	637000	422	254800
Saving [kWh]	0	0	0	20000	26000	29000	2000	1000	43000	44000	0	0	165000	109	66000

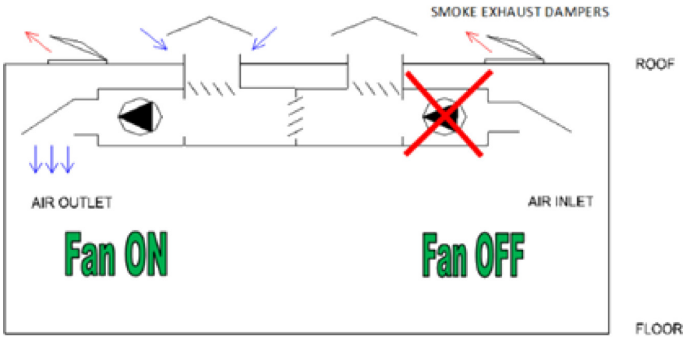

Fig. 5. Schematic diagram of the implementation of mechanical and gravity ventilation (source: own work).

The air is forced into the production halls by supply air fans (overpressure is created), and gravitationally escapes from it through the smoke vents. Schematically, the implementation process of ventilation in the model plant is presented in Fig. 5.

The implemented solution has reduced electricity consumption and has made large financial savings on a yearly basis possible. The value of energy reduction, CO_2 and saved costs is shown in Table 2. The values presented in Table 2 illustrate the scale of savings that can be achieved through in-depth analysis of production and non-production processes and building infrastructure. The biggest savings are observed in the spring months (April-June) and autumn (September-October). It is related to weather factors that have a big impact on achieving the maximum saving effect and eliminating waste. Weather factors that have a negative impact include rainfall, extreme low and high temperatures outside, and strong winds.

The scope of the investment included:

1) Installation of additional electric actuators in the smoke exhaust dampers (independent of the smoke exhaust system during a fire) with the electrical installation. The type of actuators depends on the size of the dampers and the opening angle of the dampers.
2) Assembly of additional weather control units (wind – rain).
3) Modification of the programs managing the ventilation in the factory (EBS type).

Comparing investment and planned savings resulting from lower electricity consumption, it can be concluded that the process of reimbursement of costs incurred is at the level of 3–4 years.

Conclusions

Based solely on the realized projects, in many production companies it can be stated that auxiliary processes are often marginalized in financial and environmental analysis. The occurrence of this problem is confirmed by the lack of literature that would directly associate the auxiliary processes with their impact on the environment.

However, to summarize the presented distribution of electricity consumption in the chosen chemical plant, it can be clearly stated that the non-production auxiliary processes are the main area of energy consumption. In such processes, one should look for elements of rationalization, optimization and elimination of waste. The discussed ventilation is an important element of the implementation of each production process because it is implemented

in order to improve climatic conditions in production halls for both employees and production machines.

Because of its greatest impact on the environment through the use of electricity, this process distances itself from the others in terms of energy consumption and has therefore been analyzed for savings. An important conclusion of this study is that when conducting analysis of a company in terms of electricity consumption, a consumption distribution map for the entire plant must first be made, where areas that consume the most electricity are identified and estimated.

The actions taken to save energy are a compromise between large investment outlays and the use of existing fire infrastructure to realize savings and eliminate waste in a production plant. It should be noted that the described project affected economic performance (because of savings due to lower electricity usage) and the environment (because of reduced emissions due to lower electricity usage).

The case study presented in the article showed how to analyze emissions and energy media factors that form a synthetic indicator. It is a part of a general indicator (Fig. 2) of a company's environmental impact which presents on the one hand company's environmental impact, and on the other hand, savings in the use of natural resources. General indicator can be evaluated and used in every production company. Each organization should establish its own environmental boundary conditions for the impact model that is created. Maximum allowable impact values permissible from environmental decisions, statutory values and departmental studies should be determined.

Then annual environmental impact of the surveyed enterprise should be compared with the reference values.

After adaptation of the generalized model of impact in the enterprise management processes it can be used to environmental compliance assessment, as a tool for auditors in the holistic assessment of the enterprise, comparison of the annual impact values of the enterprise in terms of production.

This paper aims to show how sustainable development can be measured by economic performance and a positive impact on the natural environment. A general indicator for the environmental impact of a company is presented in the article. Future research is needed to replicate or extend the results presented in this article. Therefore, future studies could increase the generalizability of the results.

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