Strategic environmental balanced scorecard to promote industrial ecology tools

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Abstract

The Balanced scorecard (BSC) can facilitate strategy promoting transparency and visibility to industrial ecosystems through symbiosis. The main results of this work show that outsourcing resembles and supports industrial symbiosis for the microelectronic, SMT and PCB part of the electronic value chain helping to increase the sustainability levels on global enterprises.

Keywords: Balanced Score Card, Industrial Symbiosis, Management Systems

INTRODUCTION

The concept of industrial ecology is a powerful way to increase the sustainability level of any enterprise mainly due to the fact that industrial ecology assumes all industrial systems are similar to the natural ones where only solar energy is used in a dissipative way. (Ayres 2003; Ehrenfeld 2004; Korhonen 2004). Although it is a new concept, its acceptance has been significantly increasing. A decade ago Diemer and Labrune (007) stated that Industrial Ecology would become a science field embedded in the engineering area. In fact, Industrial Ecology graduation courses are common across the globe.

However, due to the complexity of the current industrial processes, the application of such concept is not a simple task. A possible strategy is the use of intermediary steps, such as the industrial symbiosis one, in order to assist the implementation of more sustainable production cycles in the future. It primarily focuses on potential synergies for the exchange of (co-products) (Kabongo 2006). Those exchanges might take place among two or more companies, production areas such as agro-industrials (Diemer and Labrune, 2007), whole industrial sectors such as the electronic or even in larger systems such as the industrialized states. (Francis and Erkman, 2000).

Furthermore, organizational strategies, in line with market demands, demand sophisticated tools in order to sustain competitiveness. The *Balanced scorecard* (BSC) and the processes derived from such methodology can enable strategy promoting transparency and visibility to the possible industrial ecosystems available. The *Balanced Scorecard* (BSC) is a management tool that makes use of financial and non-financial key performance indicators through the cause and effect relation among such indicators. It is usually described in the company's strategic maps. (Kaplan 2000; Storch 2004; Castelli 1999). The most important objectives of the BSC are (Kaplan 2000; Bateman, 1998):

1) Clarify and translate the company's vision and strategy;

2) Communicate and associate the strategic targets and plans;

3) Plan, establish targets and align strategic initiatives and programs; and

4) Improve the flow of information and strategic learning.

The development of the BSC considers the company's strategy from four different perspectives: financials, customers or market, processes and learning and growth. They are all integrated through cause and effect relation. The learning and growth perspective also include employees and stakeholders.

Therefore this work aims to evaluate the use of BSC and industrial symbiosis as tools to increase the sustainability levels on global enterprises.

METHODOLOGY

This work uses case study methodology in a large player in the electronic sector. Therefore, the case study company covers all the value chain of the electronic sector, end to end from microelectronics to large equipment production. The applied methodology presents two major phases in order to accomplish the tasks: evaluation of industrial symbiosis and then the BSC modification for the implementation of industrial ecology concepts. Therefore, primarily the enterprise is comprehensively characterized, regarding its processes, including management systems, specially environmental management. Then, its co-products are mapped out and possible industrial symbioses are identified. After that a new BSC is proposed.

RESULTS AND DISCUSSION

This chapter is introduced as follows: brief description of the company; identification of possible co-products and connections for their internal or external use in partner companies; evaluation of available tools for the application of industrial ecology and the BSC proposal integrated to that landscape.

The company is global and as mentioned earlier has the electronic end-to-end value chain. Four of its sites were assessed. They refer to the production areas of the electronic sector. Their locations are presented in table 1.

Table 1: Production areas and their correspondents' locations for the case study company

Production Area	Sites
Microelectronics	Europe
Surface Mounting Technology	South America, North
Printed Circuit Board	South America , Southwest
Equipment Assembly	South America, Southwest

Microelectronic: The follows aspects were assessed:

- Main processes of the European sites;
- Reason for choosing those processes;
- Production Volume and main wastes; and
- Environmental programs focused on minimization and alternative use of wastes (possible co-products and industrial ecosystems).

The main conclusions were:

- The company chose to pack integrated circuits instead of manufacturing them due to cost financial benefits besides the high volume of wastes.
- Water is the largest volume waste. The type of water used at the manufacturing of integrated circuits is deionized (DI). Because of the high cost of such supply, its reuse should be promoted. However, equipment design, provided by high tech equipment suppliers, should be considered.

As the company is located at an industrial complex, na economically feasible is the symbiosis with other companies that might be able to use the wastewater without further treatment. Roughly, the annual benefits are estimated to be around EUR 130.000,00.

Surface Mounting Technology: The main co-product was lead, present in the solder paste with high concentrations of organic products. Even when the process is optimized, it's possible to find significant amounts of this co-product. And it is because of the short expiration time of the product after the package is open. Therefore, the industrial symbiosis to the metallurgical area is indicated.

The metallurgical area usually manipulates high volumes that could support the symbiosis through the high collection of co-products. This way, a regional assessment was determined to identify companies with similar manufacturing profiles. There were 7 companies eligible to that. Most of them also have advanced environmental management systems. It was possible to realize SMT would be positively impacted by the adoption of industrial symbiosis.

<u>Printed Circuit Board</u>: Figure 1 shows the production scheme of this área. Water, wastewater and water solutions with metals were assessed. The wastewater discharged after treatment could be easily reused in the toilets, which was not used prior to this analysis. On the other hand, the water solutions could be co-processed, which is considered a natural symbiosis.

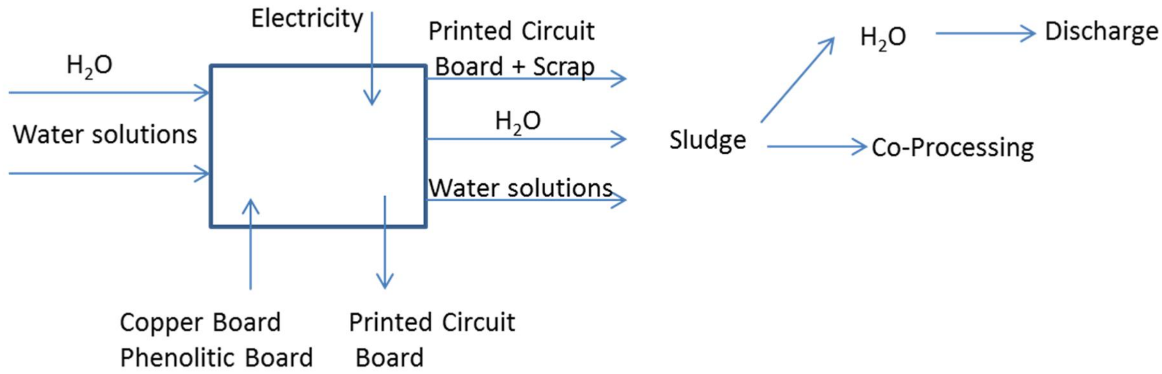

Figure 1 – Production scheme of the PCB area

The Equipment Assembly chain shows similar features compared to SMT and PCB, which enabled synchronized analysis.

After the characterization of the company, a new BSC was proposed and accepted by the company. Figure 2 shows that. The map clearly highlights the importance of the environmental spin as an enabler to the company’s financial performance. According to the BSC methodology, the strategy starts with the employee perspective focusing on the improvements and/or creation of the appropriate skill set required for the internal process optimization. The more enhanced the internal processes are, the better customer satisfaction is, which as the bottom line effect supports the profitability and sustainability of the company. Therefore, the adapted BSC, aligned to the new strategy, facilitates the visualization and comprehension of the cycles. Through follow up steps and interviews with the BSC users, it was possible to verify that the defined strategy maximizes synergy, productivity and scalability considering the legal, social and economic scenarios the sites were located in.

As a result it’s possible to observe the minimization of environmental impacts along with the continuous improvement in all other aspects of the company. Besides that, it is important to keep in mind that this philosophy and approach go far beyond legal requirement since it suggests a very proactive management system.

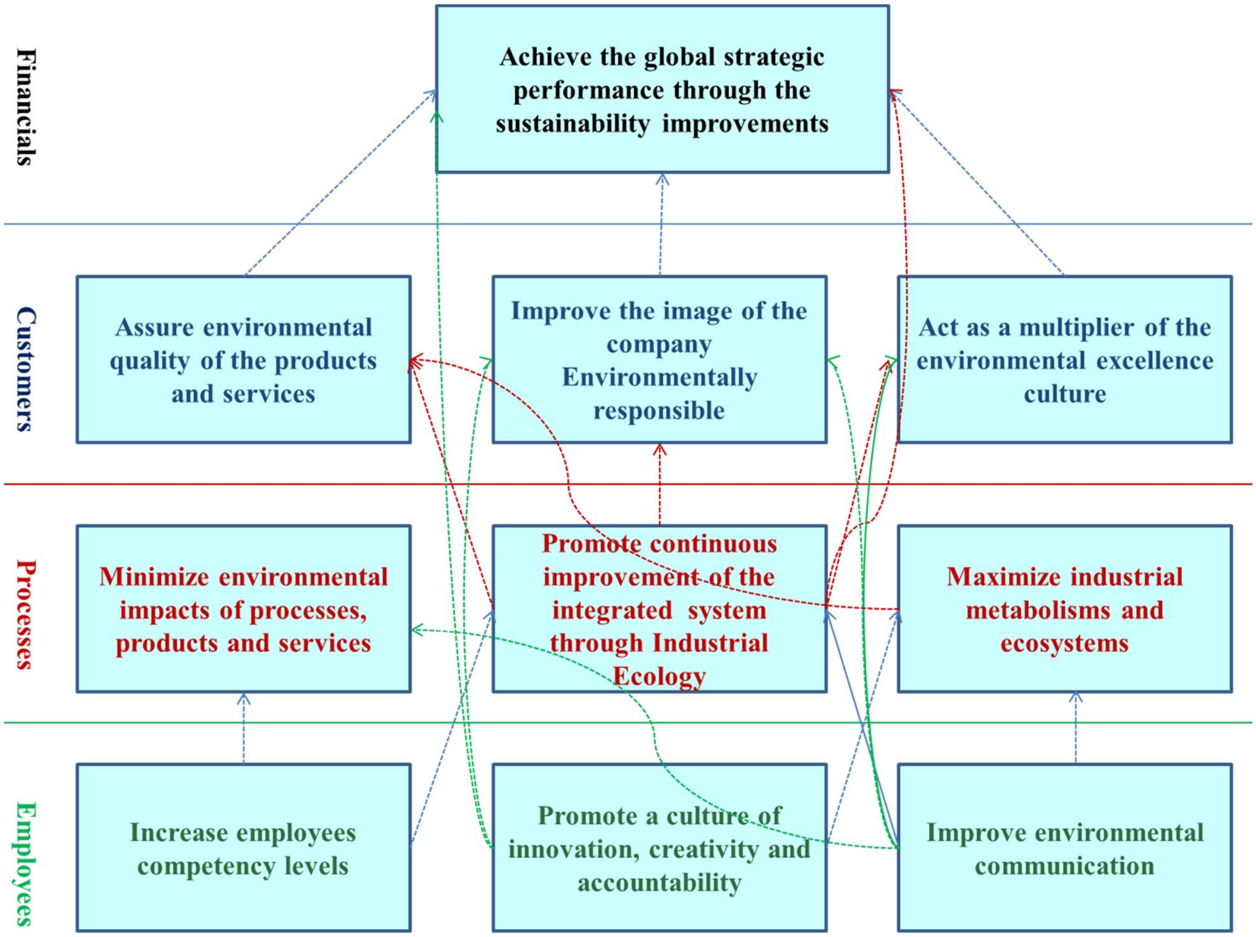

Figure 2 - BSC: Environmental Strategic Map

One of the principles of Industrial Ecology and the BSC, is the need for key performance indicators so that measurement and tracking of progress towards the goals are set. The definition of the key performance indicators was based on WBCDS and 14031: 2004, that mainly considers three types of indicators:

a) Sustainability of resources usage, through the thermodynamics inputs and the availability of resources to processes;

b) Efficiency through the losses in the transformation chain; and

c) Environmental compatibility, considering the needs to prevent environmental impacts. (KORHONEN, 2004).

The 15 indicators adopted in this study considered the targets established in the BSC. They are classified into four groups: waste management (co-products), natural resources usage, environmental investments and environmental management. Table 3 shows the indicators implemented.

Table 3 – Environmental Performance Indicators

Co-products Management	**Natural resources usage**
Co-products: coprocessed	Energy (kWh)
Co-products:hazardous wastes to landfill	Water (m3)
Co-products: hazardous wastes to recycling	Paper (kg)
Co-products: Categories II B - non hazardous (inert)	
Co-products: Categories II A - non hazardous (non inert)	
Donation	**Environmental Management**
Costs of waste management	Environmental Aspects
Income from waste management	Environmental Goals and Targets
	Environmental Awareness
Enviromental Investiments	Qualified Environmental Partners
Total Enviromental Investiments	Compliance to Legal Requirements

CONCLUSIONS

The main results show that outsourcing resembles industrial symbiosis for the microelectronic, SMT and PCB part of the electronic value chain. For the production of equipment process, the interaction between sectors is more efficient and the internal system symbiosis can still take place. Therefore, the adapted BSC aimed to identify those business opportunities through industrial symbiosis is highly productive. However, this tool also requires higher levels of employee awareness which shows its dependence on sound environmental education programs.

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