A system model to integrate the “Green Manufacturing” concept in Romanian manufacturing organisation

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Abstract. In Romania, the large majorities of the manufacturing companies consume natural resources and energy in an unsustainable manner. Over the years, the emissions of greenhouse gases have led not only to many environmental problems but also to important social and economic problems. A real solution to help the Romanian manufacturing companies to adapt to the new legislative requirements is the green manufacturing implementation. Considering the current situation, the purpose of this paper is to present a model that will integrate the green manufacturing concept at the organizational level based on the practices identified in the Romanian manufacturing companies at the operational level in the context of sustainable development.

1. Introduction

The EU environmental studies have shown that the manufacturing sector is the main consumer of energy and natural resources and release the largest amount of greenhouse gases. Because of this, all the manufacturing organisations are facing growing pressure to become “greener” or more environmentally friendly. Consequently, companies have had to review their production processes as a result of pressures from the customers, investors, community and governments [1].

The environmental experts and researchers believe that sustainable development and particularly sustainable manufacturing, is the solution for an industry to achieve balance with nature. Sustainable manufacturing combines the principles of Lean Manufacturing (waste reduction), Green Manufacturing (the 3R principle- reducing, recycling and reusing), TQM, and Corporate Social Responsibility [2].

Starting from the study that we made about the current situation of the Romanian’s manufacturing organizations regarding the sustainable development/manufacturing; the purpose of this research is to develop a model to integrate the concept of “Green Manufacturing” in Romanian manufacturing industrial organizations. The aim of this model is to chart guidelines for the all the manufacturing enterprises who want to develop eco-innovative production systems.

2. Barriers for integrate Green manufacturing in the manufacturing organization

The term “Green manufacturing” is generically defined as “elimination of waste by re-defining the existing production process or system” [3].
Even if we look at the data submitted by the EU on the benefits resulting from the application of this concept in the manufacturing organization however, the studies have shown that the implementation of Green Manufacturing is hampered by different barriers [4, 5].

A study of the relevant literature about the factors that prevent/hinder the implementation of Green manufacturing is presented in table 1.

**Table 1.** List of Green Manufacturing barriers.

| No. | Sources | Barriers |
|-----|---------|----------|
| 1.  | M. Perron [6] | 1. **Lack of available resources** (financial and human resources, lack of time and of technical knowledge, High short-term costs, Uncertain benefits) |
|     | Mittal et al. [7] | |
|     | Lee S.Y. [8] | |
|     | Walker et al. [9] | 2. **Information barriers** (language barriers, lack of awareness of their business environmental impacts, lack of awareness of benefits etc.) |
|     | Simpson et al. [10] | 3. **Internal attitudes and perceptions** (inconsistent top management support, resistance to change within company culture, disbelief of the benefits of environmental initiatives, perceived cost, high perceived effort required etc.) |
|     | Carley S. et al. [11] | |
| 2.  | Luthra et al. [12] | 4. **Weak legislation, Low enforcement, Uncertain future legislation** |
|     | Kumar S et al. [13] | 5. **Low public pressure, Low customer demand** |
|     | | 6. **The firm’s size** (a bigger size firm tends to be more willing to become “greener”) |
| 3.  | Kannan G. et al. [14] | 15 barriers: **Systematic Economic Recycling, Lack of IT implementation**, **Market competition, The government support system, Lack of organization encouragement, Supplier reluctance to change towards GSCM, Poor quality of human resources; Unawareness of customers, Top management commitment; Government support and regulations, Cost implications; Systematic and Efficient Planning, Environment Management programs, Resistance to technology advancement adoption, Lack of implementing green practices** |
|     | Mathiyazhagan K. et al. [5] | 47 barriers dived in five categories: **Outsourcing** (6 barriers), **Technology** (9 barriers), **Knowledge** (11 barriers), **Financial** (9 barriers), **Involvement and support** (12 barriers) |

As it can been seen the researchers has different or similar opinion regarding the type and the number of barriers from implementing the green concept. This difference is due to two important factors that may influence the outcome of the study: the country (USA, India, China, Germany etc.), the analyse level and the area of activity (automotive, manufacture of chemicals and chemical products, manufacture of basic pharmaceutical products, manufacture of plastic products, manufacture of electrical equipment etc.) where it was conducted.

3. **A model to integrate the concept of "Green Manufacturing" in Romanian’s manufacturing companies**

The Sustainable manufacturing considers two separate, but related, topics: first, it seeks to support the development of sustainable products and second, it promotes the development of sustainable processes [15].

In a similar way Green Manufacturing (GM) can be looked at in two ways: first is the manufacturing of „green” products (for example those used in renewable energy systems and clean technology equipment) and second the “greening” of manufacturing (reducing pollution and waste by minimizing natural resource use, recycling and reusing what was considered waste, and reducing emissions) [16].
Starting from these, the research methodology contains three stages:

1. Collecting, analysing and interpretation of the data concerning the involvement of the Romanian manufacturing enterprises in the environmental issues.
2. The development of an integration model.
3. The development of measures to further improve production systems and the development of eco-innovative actions tracking their implementation within the organization.

3.1. First stage: Collecting, analysing and interpretation of the data concerning the involvement of the Romanian manufacturing enterprises in the environmental issues

The rapid industrialization, between 1960-1989, through infrastructure development in large manufacturing factories, has led to the over-exploitation of non-renewable and renewable natural resources. This contributed to the massively pollution of the environment. In all industrial companies the damage was resulting from absence of pollution-control installations but also from ineffective management programs. As a result, Romania has become more vulnerable to geomorphologic, hydrological and climate hazards [17].

Starting from the reality presented above, the Romanian Government enacted some specific regulations for the manufacturing companies, in order to ensure sustainable manufacturing in conformity with the EU objectives [17, 18]:

- The obligation to include the indicator “resource productivity” in the expenditure budgets and financial reports.
- The obligation to provide information’s regarding the waste management, the environmental performance (processes and activities), and the application of green labelling (the number and relative share of products carrying environmental labels).
- The introduction of the “polluter-pays” principle according to which the polluter should bear the cost of measures to reduce pollution according to the extent of either the damage done to society or the exceeding of an acceptable level (standard) of pollution [19,20].

After 1989 many large manufacturing factories were closed and Romania’s industry is today dominated by SME’s. In 2015, from a total of 442,567 enterprises that operated in Romania, 441,206 are SME’s and 1,361 are large enterprises [21]. The number and type of Romanian enterprises in the manufacturing industry are presented in figure 1.

| Unit: Number | Eurostat SBS database | Estimations |
|--------------|------------------------|-------------|
| section NACE Rev. 2 | size class | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| Manufacturing | 0 - 9 | 35.348 | 30.914 | 32.554 | 37.910 | 39.376 | 40.811 |
| | 10 - 49 | 9.845 | 10.184 | 9.789 | 10.175 | 10.201 | 10.203 |
| | 50 - 249 | 3.018 | 3.223 | 2.851 | 2.742 | 2.552 | 2.370 |
| | 250 + | 722 | 731 | 650 | 638 | 585 | 535 |
| Total | 48.933 | 45.052 | 45.845 | 51.465 | 52.713 | 53.918 |
| All SMEs | 48.211 | 44.321 | 45.194 | 50.827 | 52.129 | 53.384 |

**Figure 1.** The number and the type of firms in Romanian manufacturing industry [21].

In the last “Flash Eurobarometer on SME’s, Resource Efficiency and Green Markets” the survey shows that in Romania [22]:

- 42% of the SME’s are complying with the environmental legislation but does not wish to go beyond these requirements and only 35% are contemplating doing more;
• only 25% are doing many actions to be more resources efficient (the highest percentage is 64% in Spain) and for the future 34% are planning to implement many actions;
  • regarding the reasons why the enterprise is taking action to be more resources efficient the results are: cost savings (65%), demands from customers (13%), financial or fiscal incentives (12%), creation of a competitive advantage (10%);
  • the biggest difficulty when they trying to set up resources efficiency plan is the complexity of administrative or legal procedures (29%) followed by cost of environmental action (17%), lack of specific environmental expertise (15%), difficulty to adapt legislation to the company (18%), difficulty in choosing the right actions for the company (9%).

In addition to all the above data, in the last survey published by ISO for 2013, Romania figures only with 1792 organization who have been certificated with ISO 14001 in the manufacturing industry, from a total of 8744 ISO 14001 certificate [23]. From a simple calculation result that only 3.5% of manufacturing companies had certified environmental management system.

3.2. Second stage: The development of an integration model
The proposed model has three stages like is shown in the figure 2.

Figure 2. The integration model.

I. Evaluation. The assessment of the current situation of the manufacturing enterprise process: the description and analysis of the production process analyse the waste generation for each stage, identification of the green (environmental) tools used.

II. Diagnostic. The diagnostic stage is based on the use of Environmental Key Performance Indicators (E-KPI’s).

Measuring direct and indirect impacts requires quantitative and qualitative indicators. Generally, environmental indicators are used for three major purposes [24]:
  o to give information on environmental problems;
  o to support policy development and priority setting;
  o to monitor the effects.

Key performance indicators (KPI’s) are a set of quantifiable measurements, which helps organizations in defining and measuring their progress towards their organizational goals.

F. John Reh, states that Environmental Key Performance Indicators provide organizations a tool for measuring their environmental performance: “E-KPI’s are quantifiable metrics which reflects the environmental performance of an organizational performance in the context of achieving its wider goals and objectives” [25].
To identify the most appropriate E KPi’s for the enterprise environment diagnosis we used the REM criteria:

- Relevant to the activity, operation and objectives;
- Easy to track over time;
- Measurable through quantitative metrics or qualitative surveys and interviews [26].

The Environmental Key Performance Indicators identified in the diagnosis research were established according to the following aspects: the environmental objectives of the organization, the period of time established for the diagnostic analysis (year, month), the periodicity evaluation indicators (daily, weekly, monthly) and finally the established assessment scale of the size indicators.

III. Improvement measures. Proposing improvement measures which take in account the continuous improvement and the impact on the production process, the degree adaptation of company departments, productivity, etc.

4. Conclusions
To produce in a sustainable way, the structural adjustment of the manufacturing process is the main way of increase resource productivity.

Regarding the environmental protection, on the whole, Romania scores was below average (compared to the EU Member States). Romanian SME’s are less concerned with doing something to increase their resource efficiency and the measures taken in terms of environmental protection are due only because of the legislative constraints. Compared to the EU average of 26 %, only 22 % of companies have begun to exploit the opportunities offered by the demand for green products because they do not receive as much public support to do. In addition, the studies have shown that the implementation of GM in the manufacturing organization is not that easy because is hampered by different barriers.

Starting from these, the purpose of this research is to elaborate a model for helping the Romanian’s manufacturing enterprises to develop eco-innovative production systems with the purpose of greening their products and processes while reducing the impact of their activities.

Acknowledgement
The work has been funded by the Sectorial Operational Program Human Resources Development 2007-2013 of the Ministry of European Funds through the Financial Agreement POSDRU/159/1.5/S/132397.

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