São Paulo - Brazil - May - 22nd to 24th - 2013

4th Report

INTERNATIONAL WORKSHOP

ADVANCES IN CLEANER PRODUCTION

''INTEGRATING CLEANER PRODUCTION INTO SUSTAINABILITY STRATEGIES''

Sustainable Value and Cleaner Production

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Abstract

As defined by the World Business Council for Sustainable Development in 1992, "eco-efficiency is achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the Earth's estimated carrying capacity."

Eco-Efficiency becomes then a management strategy, which aims at improving the economic and ecological efficiency of companies, attaining a higher Value with fewer inputs, materials and energy and fewer outputs, waste (i.e. pollution in the form of emissions and waste). The result is a higher Value for companies, defined as the relationship between the satisfaction of needs and the resources used in achieving that satisfaction, as well as the increase of their competitiveness.

Using the synergies between tools used by Value Management (Value Analysis) and Eco-efficiency (Cleaner Production), the Sustainable Value methodology was developed, and it integrates the three aspects of Sustainability (economic, environment and social) in Value evaluation.

The aim of this approach is to increase Sustainable Value of the study subjects (value subject being the application of the methodology to a specific subject) by evaluating their satisfaction levels taking into account environmental and social aspects. The resources used to attain that satisfaction of needs are also characterized in an explicit way in terms of environmental, social and economic aspects.

To attain these results an eight phases working plan, to be developed by a team, is presented.

To test and validate this methodology some projects have been developed, involving 19 enterprises where the approach was implemented. Those companies, in most cases Small and Medium ones, came from different activity areas and different regions covering almost the whole Portuguese territory.

Also the results emerging from the application in the different companies are presented as well as conclusions and suggestions about some conditions that must be fulfilled for the success of the introduction and implementation of these approaches in a company.

Keywords: *Sustainable Value, Cleaner Production, Eco-efficiency, Value Analysis, Competitiveness*

Value and eco-efficiency

Most times Value Analysis (VA) has been identified, inadequately, as a reduction cost methodology but

it is much more than this and it is enough to look at its definition: an organized and creative approach using a functional and economic design process which aims at increasing the Value of a VA subject (EN 1325-1:2011). Value is defined, in a Value Management (VM) context, as the relationship between the satisfaction of needs and the resources used in achieving that satisfaction (EN 1325-1:2011) (Fig. 1).

$$\text{Value} \quad \alpha \quad \frac{\text{Satisfaction of needs}}{\text{Consumption of resources}}$$

Fig. 1. The concept of Value

From both definitions can be easily concluded that the increasing of Value in a VA subject is not necessarily the result of cost reduction.

In Value definition (fig. 1) the symbol α means that the relationship between satisfaction of needs, often called performance and the used resources is only a representation. Value is not an absolute measure, but a relative one, and can be differently perceived by the different stakeholders involved in the process. It is an indicator that enables to compare the existing Value with the ones resulting from the VA study proposals and evaluate them. According to fig. 1 there is a Value increase if a lower use of resources and/or a higher satisfaction of needs is attained. As to resources quantification almost always only the economic aspects are taken into account. But with the increasing requests towards Sustainable Development, companies can no longer ignore the other two aspects of Sustainability: environment and social.

As defined by the World Business Council for Sustainable Development (WBCSD) in 1992, "eco-efficiency is achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the Earth's estimated carrying capacity. Various authors find eco-efficiency can help the sustainable development of any kind of business activity (Safari, 2008; Howgrade-Graham and van Berkel, 2007; Van Berkel, 2007). Moreover, other researches demonstrate eco-efficiency is particularly useful for Small and Medium Sized Enterprises (SME) in developing countries (Byung-Wook et al., 2006; Sangwon et al., 2008).

Eco-Efficiency becomes then a management strategy towards sustainable development, by improving the economic and ecological efficiency of companies (attaining a higher Value with fewer inputs, materials and energy and fewer outputs, waste; i.e. pollution in the form of emissions and waste). It lays on the prevention of materials, water and energy losses at the origin, leading to functioning costs reduction and to the improvement of the products environmental profile. The result is a higher Value for companies as well as the increase of their competitiveness particularly for Small and Medium Enterprises. In the past, companies looked at the environment and sustainable development as problems, costs and risk factors, but today they begin to see them also as opportunities – sources of efficiency improvement and growth. For example, if you save energy, you reduce the costs as well as unwelcome outputs such as emissions. Using the words of Bjorn Stigson, President WBCSD: "This is what eco-efficiency is all about: combining the goals of business excellence and environmental excellence, and creating the link through which corporate behavior can support sustainable development."

The complementarities between eco-efficiency (doing more with less) and value analysis (satisfying needs using fewer resources) are then visible. Using the synergies between tools used by VM (VA as an example) and eco-efficiency (Cleaner Production CP– UNEP 1994), the Sustainable Value methodology was developed, and it integrates the three aspects of Sustainability (economic, environment and social) in Value evaluation.

The aim of this approach is to increase Sustainable Value of the study subjects (value subject being the application of the methodology to a specific subject) by evaluating their satisfaction levels taking into account environmental and social aspects. The resources used to attain that satisfaction of needs are also characterized in an explicit way in terms of environmental, social and economic aspects. Step by step, a diagnosis of environment, economic, social and functional problems of the study subject takes

place followed by solutions search to give answer to the problems that were found. Those solutions will be evaluated taking into account all those aspects thus contributing to increase value in a sustainable way.

Sustainable Value Methodology (SVM)

The objective of the methodology is to increase Value. This will be achieved not only in the traditional way, which means merely economical and needs satisfaction evaluation, but taking into account other aspects that must be satisfied such as environmental and social ones. To create Sustainable Value (SV), the methodology starts from the environmental, economical and social characterization of the used resources by the enterprise and the evaluation of the level of satisfaction attained by the product and / or process that constitutes the study subject.

To attain these results an eight phases working plan, to be developed by a team, is proposed:

Phase 1. General data from the company - the company collects its general data: identification, labor conditions, staff flowchart and relationship with stakeholders

Phase 2. Specific data about the project - the company top management must define the study subject (product and, or process), the working team, the objectives and constraints. If the study subject is a product more information has to be collected namely in what concerns the market.

Phase 3. Global inventory – this is the approach most arduous phase not only due the amount and variety of the needed information, but also to its organization. Usually the company has this data but not organized in the way to be used within the methodology. This inventory is structured based in the Cleaner Production approach and the costs (labor and equipment) are quantified. The working team designs the study subject manufacturing diagram. All the unitary operations are identified as well as the inputs and outputs of materials, energy and water. The study subject is divided into its components, and displayed in a diagram.

The detailed costs for each operation related to the components are quantified in what concerns labor, equipment, energy, materials, water and emissions and waste management. The diagram is then completed leading to a cost model. The team lists all the raw materials, components, auxiliary materials, packages, water, energy, final products, intermediary products, waste, emissions, trade waste and noise. All of them are characterized (in environmental, economic and social terms) and quantified thus allowing to build the cost model as well as to detect the manufacturing inefficiencies (mass balance). An immediate analysis of this data, mainly in what concerns the effects on the environment and the improvement opportunities leads to starting points for the formulation of improvement proposals.

Phase 4. Functional analysis is one of the main phases of the Value Analysis (VA) methodology, and is a systematic process to describe completely the study subject's functions and their relationships. They are systematically identified, characterized, classified and evaluated (EN 1325-1, 2001). The study subject is no more analyzed only as the assembling of components, but is also characterized by a set of functions. The level of satisfaction of the user will depends on the performance of those functions. In order to contribute for a progressive orientation of companies towards sustainability it is essential that when performing this Functional Analysis phase, the stakeholders' needs (expressed in functions terms) take into account not only social and economic worries, but also the environmental aspect, so that companies will adopt the new concept of Sustainable Value (fig. 2).

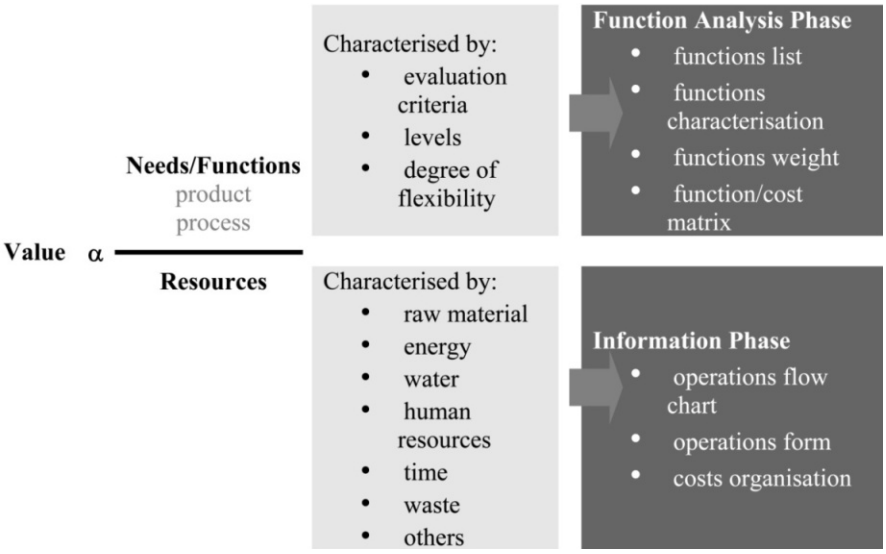

Fig. 2. Value definition

The evaluation of the relationships between cost and function as well as cost and importance results from this phase. The level of performance is defined and finally the Sustainable Value is estimated. At the end of the phase it is possible to quantify the Sustainable Value of the study subject. This indicator will be compared later with the one that will be obtained by implementing the proposals generated in phase 6.

Phase 5. Problems synthesis – the problems detected during the previous phases are now synthesized: the relationship with stakeholders (phase 1), the eco inefficiencies of the process and its environmental impacts (phase 3) and legal non conformities. And from the analysis of the cost function matrix (phase 4), functions and components with high costs are identified. Eventual non conformances between costs and relative importance of functions are detected. The working team evaluates the performance of the study subject and identifies areas, activities or operations where attention must be focused. This information is essential to identify and helps generating ideas to solve the detected problems and therefore to improve the users' satisfaction thus contributing to improve the study subject Sustainable Value.

Phase 6. Previous identification and selection of ideas – often called the creativity phase. It is now the right time for the working team to generate ideas to improve the study subject through creativity sessions or research of already existing solutions for similar problems. Sometimes the team is enlarged with external elements always that the necessary expertise does not exist within the team and no confidentiality problems arise. Using creativity techniques (brainstorming being one of them) the team produces new ideas which will be listed, classified and eventually grouped in order to make a pre selection of those whose viability will be analyzed during the next phase.

Phase 7. Viability analysis – once again the three aspects of Sustainability will be taken into account. Therefore the team will now analyze the viability of the ideas, coming from the previous phase, in what concerns technical, environmental and social aspects and evaluates and selects the ideas taking into account their Sustainable Value (relationship between needs' satisfaction and used resources).

Phase 8. Action plan - action plans are defined being their implementation dependent on Top Management decision. As in other similar methodologies, it must be emphasized the need of top management support, without which no application will be complete. Interesting results can be achieved at all levels, but before their implementation they will be nothing more than ideas on a note book as a result of an exercise. The application of Sustainable Value methodology will only be effective after implementation.

Practical applications

To test and validate this methodology some projects, involving 19 enterprises where the approach was implemented, have been developed. Those companies came from different activity areas and different regions covering almost the whole Portuguese territory.

AVORIS Project

This Project involved an Entrepreneurial Association of the region (Torres Vedras) where it was developed, five companies and LNEG as the partner for the technology transfer. It was financially supported by Lisaction program. The objectives of this project were: increase the Value of companies and its products, develop new competencies, promote the demonstration effect, transfer knowledge and promote the development of design and applied Innovation. After a year of an integrated application of tools such as Value Analysis, Cleaner Production, Ecodesign and Life Cycle Assessment it was possible to obtain improvements in what concerns Sustainable Value in processes and products (either the development of new ones or the reformulation of existing ones) and new research opportunities arose namely in what concerns a more objective integration of social aspects in this kind of approach. The companies were either micro or small ones, from 8 to 96 workers and laboring in metal mechanics, plastics and detergents. Due to their dimension in some companies there was the need to involve external elements, besides the company's elements and the researchers from LNEG and the association, in order to have a team with critical dimension.

The SVM working plan was followed step by step, being the Global inventory, phase 3, the longer one. At the end of the project all the companies had proposals deeply analyzed and supported for immediate implementation, if that was the wish of Top Management, together with others that needed a further development for a later implementation.

DEUSA Project

The Sustainable Value Methodology was developed and the corresponding working forms were elaborated in order to support the application of SVM within companies. The different steps of DEUSA were:

a. Three entrepreneurial associations showed their interest in applying the SVM in 7 companies. They got financial support to the development of DEUSA project with the following objectives:

- To improve the opportunity of increasing Sustainable Value of companies and their products and to promote Eco-efficiency in the companies involved in the Project through the implementation of preventive management strategies and tools such as CP - to do more with a better quality with less materials, energy and water and Value Analysis - to evaluate the influence of performance improvement (economical, environmental and social) of a product and, or process in the creation of more Value for the company.
- To develop new competences in order to contribute for more responsible companies.
- To promote the demonstration effect in Aveiro region.

b. The top management of each company engaged themselves personally in the project and in the application of the SVM. They signed a letter of agreement and paid a symbolic fee to participate.

c. LNEG team trained the SV working teams from every company involved - company internal team plus elements from the associations; an e-learning platform was designed and adapted to the SVM application; and this platform was online for two more years after the end of the project.

d. Each SV working team with the support of the LNEG team implemented the SVM during 12 months.

e. After validation the methodology was published in a Manual (available in Portuguese)

All the companies, in the DEUSA Project, were SME and certified either at the product or the process level. Two of them were larger, with 280 and 240 workers. The smallest one had only 17 workers.

They were all in the metal mechanics area. Five of them selected the process as the study subject, and the other two selected the product. The Sustainable Value concept worked and helped the companies to direct their options towards Sustainability. The Sustainable Value Methodology used enabled the companies to diagnose the main problems concerning their manufacturing processes and products (for those that made an integrated study of the product) leading to the quantification of the total costs including the environmental and social ones.

Globally the application of the Sustainable Value Methodology led to improve the functional performance of the study subjects, improving the satisfaction of user's needs, taking into account a pollution preventive approach. Therefore the eco efficiency principles were used (namely the progress in recyclability and product durability, the reduction of toxic dispersion and the maximization of the use of renewable resources and of the service intensity) to quantify the increase in the satisfaction associated to each function; to reduce costs associated to the study subject, taking into account the minimization of resources intensity (materials, energy, water, operation time, …) of products and processes.

Eco efficiency project in quarries - EEIE

This was an Eco efficiency project in quarries located in the largest area for marble extraction in Portugal, in Alentejo. The project was designed to apply the sustainability concept in a sample of companies of marble extraction and transformation. Several stakeholders cooperated in the project: an institution from the Portuguese scientific system, a Technological Centre, the local university, the regional entity for coordination and development as well as the local population. The adopted strategy used new cleaner production models together with Sustainable Value improvement, leading to the rationalization of the exploitation, the involvement of economic agents and the orientation of the management of production processes towards eco efficiency. The challenge was to have the extraction industry managing efficiently the resources from which the business depends, according to sustainability principles.

This approach enabled the support, to the companies involved, in the improvement of sustainable value in their processes, products and services. The improvement, in each company, of the relationship between the economic, environmental and social performances and the involved resources, led to the improvement of their eco efficiency and competitiveness, based on an innovation entrepreneurial culture. The active involvement of the different stakeholders, strengthened the results and created a multiplying effect that helped the dissemination of this strategy to other companies of the sector involved in mineral extraction. With the results attained, besides different opportunities for improvement, related to materials, water and energy use that were identified in the companies of marble extraction and transformation, also some concrete proposals were selected, and other specific benefits were discussed, such as the land and vegetation destruction, as well as the fauna, leading to great rundown areas. Therefore the problems of environment plans and landscape recovery emerged, having in mind the concept of ecological recovery.

Results

Different aspects emerging from these applications will be analyzed.

Companies' dimension – as to the number of company's workers involved (fig. 3), they vary in this sample from 5 to 280. Deusa project has the higher number of workers, then Avoris and the smaller one is for EEIE. Facing the results and experience, one conclusion can be taken that this approach is possible, with some small adaptations, no matter the dimension of enterprise. The relation between the number of workers and income is shown on fig. 4.

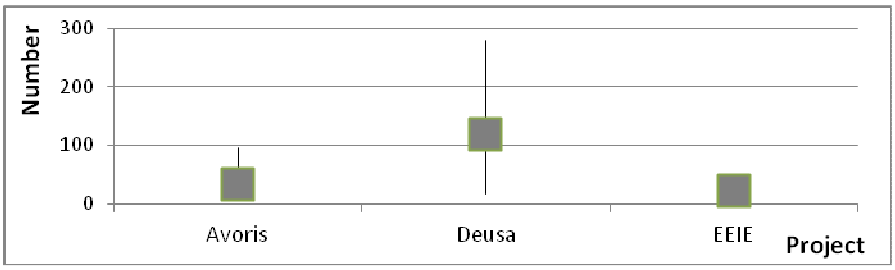

Fig. 3. Number of workers

Creativity – the total number of ideas, (fig. 5) resulting from the application of this methodology varied from 6 to 93, and the % of those that can be implemented in a short term from 18 to 70% (fig. 6). Although Deusa project has the higher average number of ideas followed by Avoris and then EEIE, the lower % of ideas to be implemented in a short term happens with Deusa.

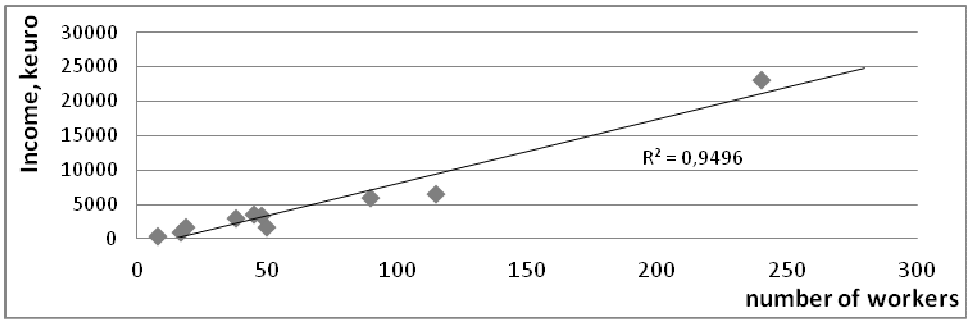

Fig. 4. Income *vs* number of workers

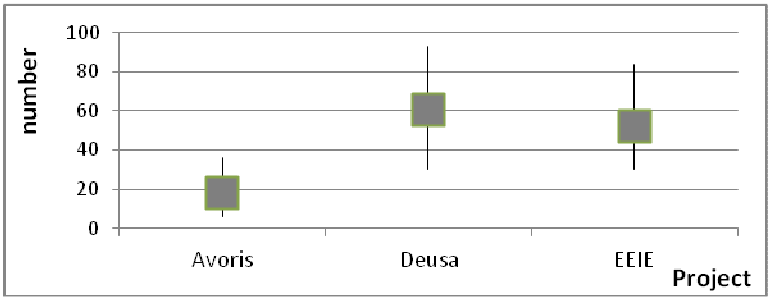

Fig. 5. Number of ideas

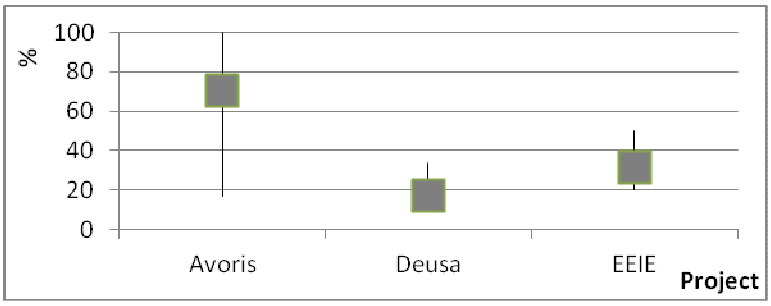

Fig. 6. Ideas to be implemented in a short term

Ideas Evaluation - the ideas were classified according to Cleaner Production techniques items: equipment modification, product modification, good housekeeping, input substitution, recovery/reuse (fig. 7). Most of the ideas resulting from the methodology application to the process have to do with equipment modifications (Avoris) and good housekeeping (Deusa and EEIE). Product modifications

were relevant, in Avoris project, related to materials reduction in packages. The Input substitution in Deusa and EEIE has to do with the option for materials less toxic and the recovery/reuse in EEIE is the result of marble waste valorization. When the study subject is a product most of the ideas have to do with product modification. The eco efficiency principles were also used to classify ideas (fig. 8).

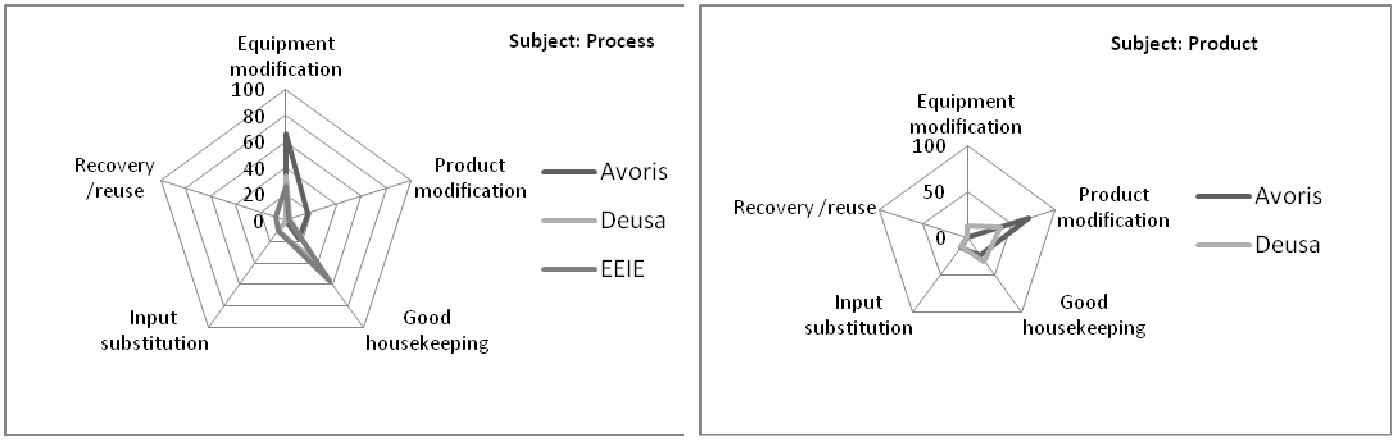

Fig. 7. Ideas distribution according to CP techniques

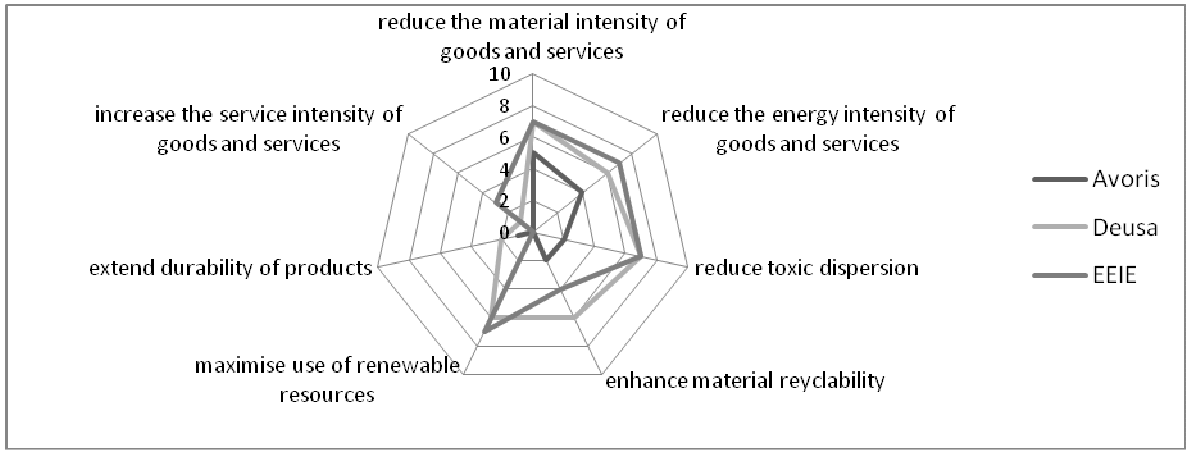

Fig. 8. Ideas distribution according to eco efficiency principles

Sustainable Value evaluation - this indicator (fig. 1) is quantified through the relationship between satisfaction of needs (also called performance) and consumption of resources.

As to performance its variation for the three projects is shown in fig. 9. The methodology implementation resulted in the performance increase for all the companies involved in the projects (from 8 % - Avoris to 57% - Deusa)

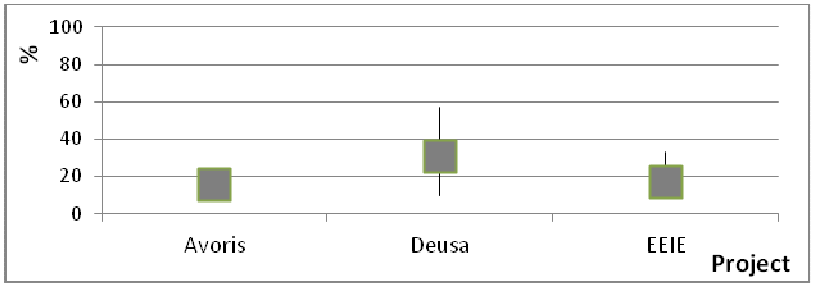

Fig. 9. Performance variation

The consumption of resources, quantified by the costs involved is shown in fig. 10. In most cases there

is a cost reduction. The cases where this does not happen have to do with the accomplishment of user's needs either by designing a new product or reformulating an existing one with different characteristics. The resulting Sustainable Value variation is shown on fig. 11.

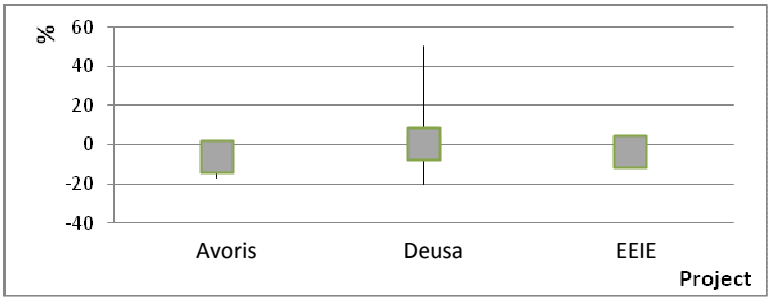

Fig. 10. Cost variation

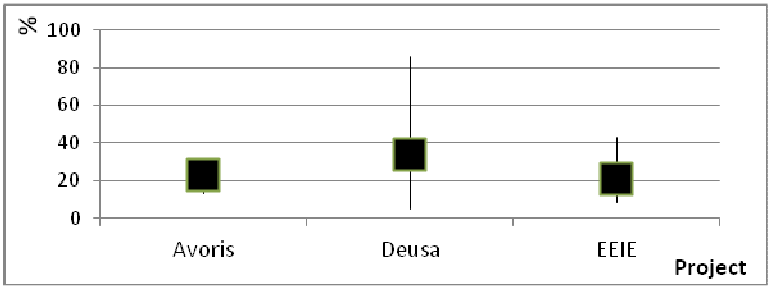

Fig. 11. Sustainable Value variation

The objective of this methodology is to increase Sustainable Value of the study subject and it was met in every case with different levels of fulfillment. Even in the cases where there was a cost increase the resulting performance increase was higher and therefore Value increased in relation to the initial one.

Anyway it must be reminded that Sustainable Value is not an absolute measure, but a relative one, an indicator that enables to compare the existing Value with the ones resulting from the study proposals and evaluate them.

General conclusions

The use of Sustainable Value Methodology enables the diagnosis of the main problems related with processes and products and the quantification of the used resources, namely the environmental and social ones. Taking into account the three aspects of Sustainability the following possible results can be referred:

- Economic – manufacturing processes diagnosis and improvement; costs identification, control and reduction; inputs reduction, at the process level (materials, energy and water) thus leading to the enterprises' eco efficiency improvement
- Environmental - diagnosis of manufacturing; implementation of environmental best practices; reduction of materials energy and water consumption; waste preventive approach and reduction of toxic dispersion which results in the companies' eco efficiency improvement
- Social – better internal and external communication and change in behaviors and attitudes namely in what concerns hygiene and safety conditions, at work; development of new competences and adoption of a social responsible behavior within enterprises.

A better definition of the users' needs and therefore a more adequate answer to them either through the reformulation of existing products or the design of new ones, are also aspects to be mentioned as a consequence of the implementation of this approach. Sustainable Value improvement of the study subjects will be reflected in the competitiveness of the company.

For the success of the introduction and implementation of these approaches in a company some conditions must be fulfilled. The first one, which is common to other methodologies alike, has to do with top management effective support. Along the methodology phases there are crucial points whose responsibility is exclusively centered on those managers – at phase 2 the company top management must define the study subject (product and, or process), the working team, the objectives and constraints. The application of the methodology can lead to very stimulating results but they will only mean a Value improvement, either through cost reduction, satisfaction increase or both, when implemented. If they are not implemented they will only represent consumption of resources, human labor and motivation, tests when needed, materials if a prototype is produced. These costs will only be an investment from the moment the ideas are no longer only on the paper but implemented.Top management decision is needed to make it happen. Another key element in this process is the working team mainly built of internal elements to the company and with experience connected to the study subject. This is not merely one more element in the company's organization but it lasts as long as the project and will disappear, as structure, when the action plan is presented. Once again top management is responsible for its composition and members' availability and motivation.

In a time of a world crisis companies face daily difficult challenges to survive, in a market where competitiveness is always growing and where the economic and social development, the workers welfare, and the reduction of products and processes environmental impact must be guaranteed. To answer this challenge the Sustainable Development paradigm cannot be ignored, which according to Brundtland Commission (1987) must answer to present needs without risking the future generations' ones. This means an economical growth which does not deplete the renewable resources nor destroy the ecosystems and contribute to reduce social inequalities at world level.

The implementation of these methodologies that enable a deep diagnosis of products and processes, the searching of solutions with a higher Sustainable Value obtained by diminishing resources (less materials, energy and water inputs and less waste and emissions outputs), and the increase in needs' satisfaction, will be a powerful contribute to win the challenge.

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