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DESIGN FOR ENVIRONMENT: A QUESTION OF COSTS AND BENEFITS

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Summary

In the last years, the attention paid to Sustainable Development problems has certainly helped in sensitizing the industrial world, caused either by new specific standards and regulations oriented to the environmental impacts reduction, or by the more and more important request for “green” products.

The main difficulties concern the wrong industrial approach to the problem, which consider environmental requirements either as an additional cost, or as a reduction of aesthetical or functional product properties: the solutions carried out, in fact, mainly consist in ex post modifications, namely “end-of-pipe” solutions.

The aim of our research is the development of a Design Methodology, which takes in account not only the direct environmental impact of products, but also makes their development economically feasible, extending their life, and foreseeing their re-use, disassembling and recycling.

1 Introduction

The environmental problems have risen to an importance and clarity which cannot be either disregarded or undervalued: in the past century Mankind, owing to his way of life and to his industries, in a very short time influenced the environmental conditions in such a way that a great danger for the man survival arose.

A deep observation of the production activities, that exists at present in all industries, makes evident how the purpose of the work always aims at the achievement of some product features like: aesthetics, reliability, low cost, safety, high quality. Moreover it is noted that the efficiency of a factory is always based on its capacity of increasing more and more its production, looking for new markets and searching for a continuous increase of the industrial structure. In these addresses it is not possible to single out, at least in an evident way, the preoccupation concerning the effects which this way of dealing may have on Mankind and on the environment in which Mankind lives. Some forecasts, based on the environmental impact due to the products and to the industrial processes, allow us to foresee without doubt that it is necessary to substantially modify such trend. At present it is understood that a development which does not take account of the environmental effects causes very substantial ecological damages (ozone hole; greenhouse effect; high consumption of energy and of raw materials; smog; destruction of the natural resources owing to acidification and eutrophisation; diffusion of toxic substances in air, water and land; accumulation of wastes, and so on).

On the other hand, in spite of the huge technical and technological progress achieved during the last years, considering environmental requirements as an additional cost, or as a reduction of aesthetical or functional product properties, has made the possibility to enhance products and processes’ environmental performances very hard, while simultaneously improving companies economical earnings.

Particularly, the problems connected with the high costs for reducing environmental impacts have to have been related to cultural and knowledge lackness, result of an atavic heritage, which continues to considerate environmental costs as a weight which it is necessary bear.
Further more, we also have to take in account of industrial realities, as the Italian one, mainly formed by small and medium size companies, in which the need of being competitive disagrees with the inplementation of sustainable criteria. Such behaviour significatively contributes both to the delay in acknowledging new “green approaches” (above all Agenda 21), and to assess in a wron manner environmental costs.

It is also important to underline the necessity to find some criteria through which the environmental impacts could be reduced, so to make it economically feasible at the same time.

In such a context, the importance of designers clearly stands out. In fact, they have a great influence on environmental impact reduction since, once a product is designed, its impact is largely fixed. The benefits of making “green” decisions in the early stages of the product design can be substantial.

2 Background

At present the research,carried out at Universities, Scientific Institutes and Industries, has provided some important results, not numerous, but really useful because they show some addresses which can be followed for a wider action. The problems to face are very numerous and often linked together with unclear modalities.

In most past situations, the effects of a lot of products and processes on the Environment were completely neglected during the whole design process: dangerous wastes were eliminated only taking into account the economic convenience; the inefficient use of energy has brought about high operational costs; rejects weren’t differentiated on the basis of the materials production, manufacturing, distribution, and also consumers hadn’t considered environmental aspects in replacing products, disregarding their reuse and recycling.

Only recently, singling out such problems inspired the use of technologies more oriented to the Environment, with the aims to make up for both the past, and the present pollution, and mainly to take in account the future one. Following such general objectives, three main aims were carried out:

1. Reducing or minimizing the use of not renewable sources.
2. Managing renewble sources in order to ensure a high sustainability.
3. Reducing toxic and noxious emissions, with the final aim of eliminating them.

For the solution of the above mentioned problems the designers seem the more suitable people, both for their basic knowledge and for their ability to perform usually activity of “problem solving”.

The task of Design for Environment is to pursue these aims in the most economically feasibile way as possible, intending with the term “Design for Environment” (also called “Green Design”) the development of environmentally friendly products and processes, towards the implementation of certain design strategies, in order to consider environmental problems, and the use of pertinent design methods for synthesis and analysis. The challange of “Design for Environment” is to modify the traditional design and production processes, in order to include environmental considerations in a systematic and effective manner.

3 Design Methodology

In the ambit of each one of such general aims to face the problems connected with environmental impacts, a lot of Design Tools have been proposed, characterized by different, ways of use, complexity, effectiveness and efficiency, and mostly oriented to solve only specific problems. Nevertheless, the evolution of market requirements in the last years has deeply transformed the designer way of thinking and operating, obliging designers to consider a great number of parameters and constraints.

Among the whole, it is deemed that the “Design for Environment” is the most interesting and useful tool for Designers. It includes in design stages all aspects of a product’s life, starting from the choice of materials, through the product manufacture, utilisation, distribution and end of life. Moreover it also includes the highest design level, concerning the passage from the product-object to the product-function, through which the generation of new ideas is performed, e.g.: dematerialisation, goods-sharing, function optimisation.

Since every necessary action to reduce the Environmental Impacts strictly depends on its cost, the study about costs related to envronmental aspects was also deepened, taking into accout all the product Life Cycle. On the basis of such research were considered the following Design Tools:

1. *Choice of optimal design solutions*
   - 1.1. Design Environmental Review (DER)
   - 1.2. Quality and Environmental Function Deployment (QEFD)
   - 1.3. Value Analysis (VA)
2. *Choice of production processes*
   - 2.1. Design Environmental Review (DER)
   - 2.2. Asseblability Evaluation Method (AEM)
   - 2.3. Extended Assemblability Evaluation Method (EAEM)
   - 2.4. Design for Disassembling (DfD)
   - 2.5. Recyclability Evaluation Method (REM)
   - 2.6. End-of-Life Strategy Environmental Impact Model (ELSEIM)
   - 2.7. Design for Upgrading (DfU)
   - 2.8. Design For Modularity (DfM)
3. *Reliability improvement*
   - 3.1. Fault Tree Analysis (FTA)
   - 3.2. Fish Bone Diagram (FBD)
   - 3.3. Failure Mode and Effect Analysis (FMEA)
4. *Costs assessment*
   - 4.1. Functional Cost Analysis (FCA)
   - 4.2. Activity Based Costing (ABC)
5. *Techniques for rapid evaluations and results representation*
   - 5.1. Environmental Product Life Cycle Matrix (EPM)
   - 5.2. Ecodesign Strategy Wheel (ESW)

5.3. Triangle Tool (TT)

5.4. Ecodesign PILOT

All such Design Tools were implemented in the Design Strategy: for each of these were defined the proper moment of use and the proper sequence in order to reach results with the maximum effectiveness during each phase of the Design Process (the Methodical Design Process by the School of Rome).

4 Case Study

To verify the effectiveness of the study performed, the developed approach was implemented to a real case, and in particular to the Re-design of a multifunctional car to be used in an urban context, collaborating with an Italian company specialised in transforming and assembling vehicle bodies (in Tab. 1 were shown main characteristics of the vehicle).

Characteristics		
1.	Mechanical System	Multifunctional vehicle with a low environmental impact
2.	Dimensions:	
	- lenght	3100 mm – 3500 mm
	- width	1250 mm
	- height	1650 mm
3.	Propulsion	Zero or low emissions engine / motor
4.	Maximum speed	45 km/h
5.	Range	60 km
6.	Use	Equipments and people transportation in traffic limited areas
8.	Production per year	1500 units

Tab. 1: General characteristics of the vehicle.

Defining the exact meaning of “green car” is surely a difficult task: in fact, traditional design concepts have to be balanced (performances, price, safety) and simultaneously adapted to the producers bottom line. The consciouness recently acquired regarding environmental problems and the knowledge of tools aimed to reduce these, are improving in companies, but it is also clear that such tools aren’t yet used in a systematic way, in a well stated design procedure, as well as Design for Environment methodology can allow.

4.1 The Re-Design of the vehicle

The re-design of such a vehicle represents a direct attempt to show how using this approach in the right way, it is possibile to reach green performances and at same time a considerable costs reduction. With this aim in mind, in developing our task, we took into considerable accout the use modular structures and components, focusing the study on the analysis of the chassis.

In designing this vehicle many choices, suited for reducing the environmental impacts, were carried out: particularly, optimal results were achieved using:

- Quality and Environmental Function Deployment (QEFD), in choosing optimal design solutions (Fig. 1);
- All the design tools mentioned in the second group (Choice of production processes);

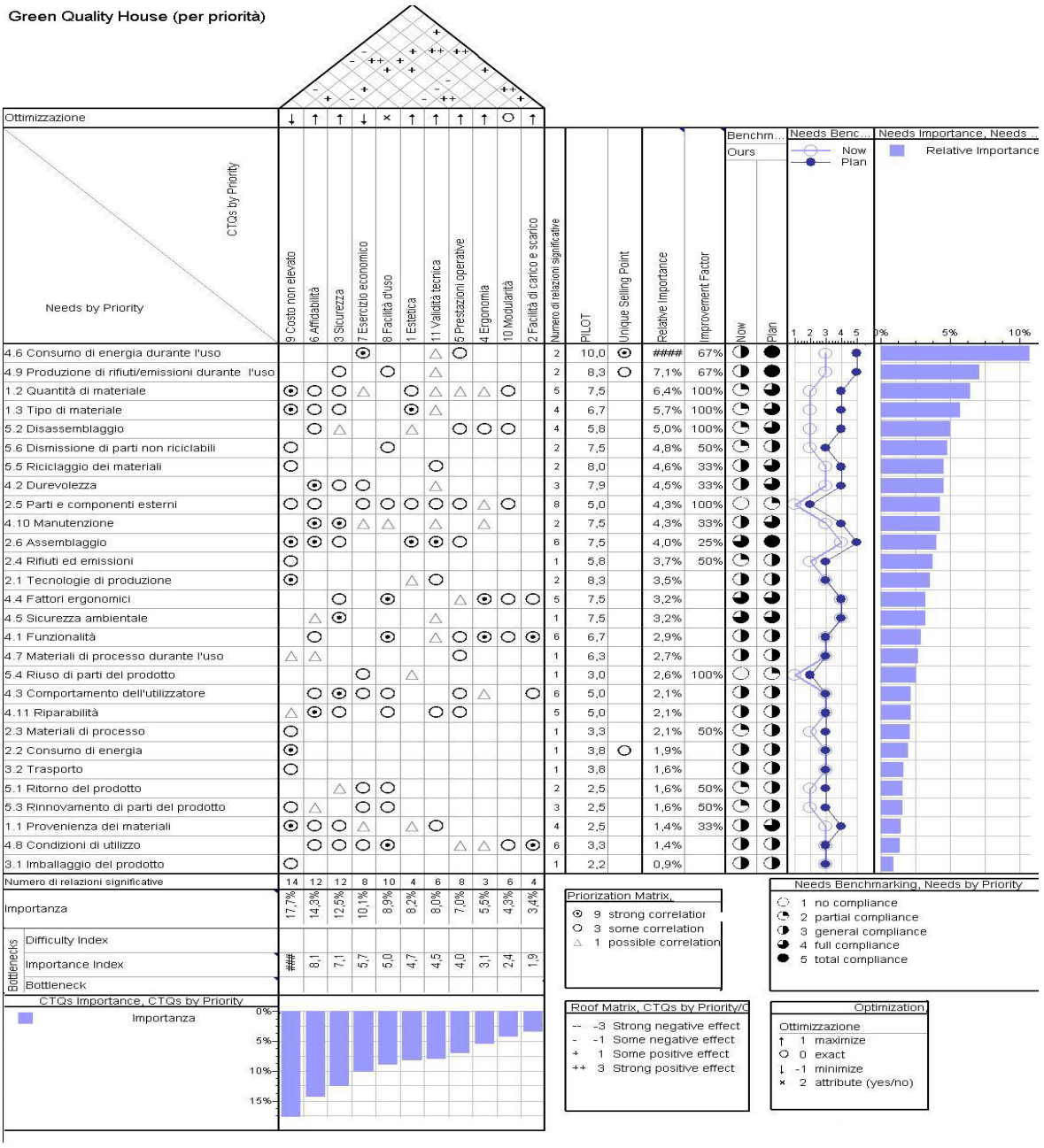

Fig. 1: The first phase of Quality and Environmental Function Deployment method.

- Ecodesign Strategy Wheel (ESW), Triangle Tool (TT) and Ecodesign PILOT from the fifth group;
- Functional Cost Analysis (FCA) for the costs assessment.

The versatility of the vehicle has been achieved not only improving the range (kilometres per tankful) and reducing dimensions, but mainly developing different solutions which can make it suitable for different aims, towards the use of a set of modules easily replaceable: in the following picture are shown different solutions (Fig. 2) and in detail the modules housing (Fig.3).

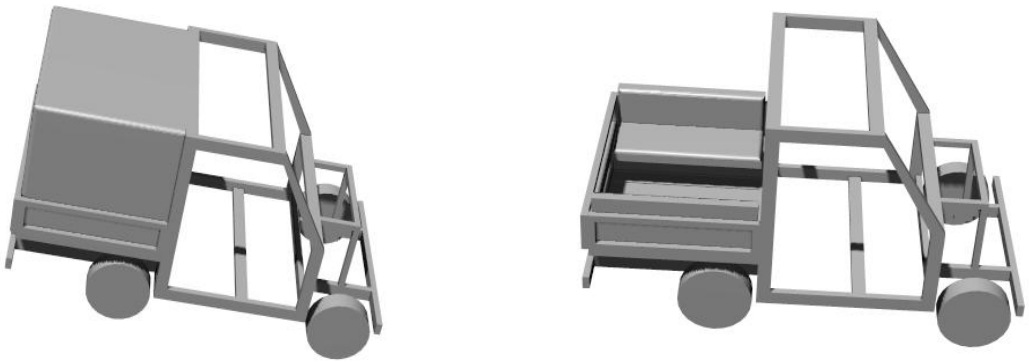

Fig. 2: Examples of different solutions

4.2 Costs Assessment

The costs evaluation carried out by using group 4 methods, has shown that the design solutions adopted (Aluminium 6063 T6 for the chassis, structural shapes with a simple geometry, welded joints, modular structure) allow both a longer life span, and a sensible environmental impact reduduction, and mainly lead at the same time to a cost reduction, higher than 15% compared with a similar vehicle traditionally designed.

Moreover, it is also important to underline other positive aspects, such as:

- Achieving new market shares (beneficiary: producers)
- Lower prices during the wole life cycle (beneficiary: customers)
- Shorter time to market for introducing new solutions
- Ability in bringing new trends and future needs forward.

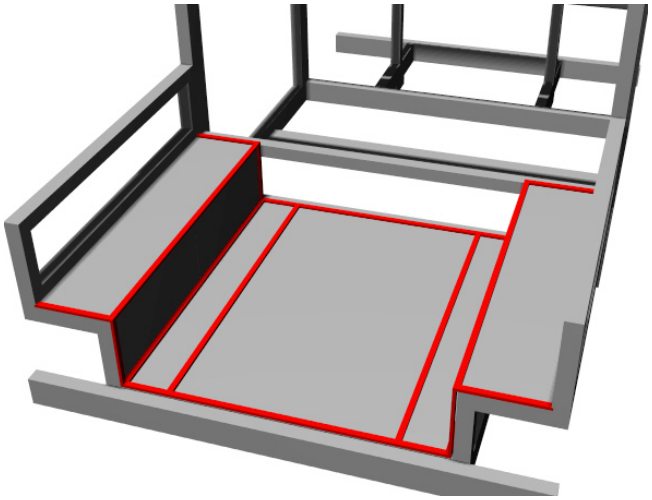

Fig. 3: Modules housing.

5 Conclusions

Design has nowadays become a very complex task. It should therefore take into account the whole life cycle of a product, and it should bear in mind market needs and expectations, and the Design Methodology shown surely ought to be applied to the “Design for Environment” of any type of mechanical product. In fact, it allows a systematic development of design, that makes the occurrence of mistakes or the pursuance of bad solutions difficult.

The results achieved could be considered very good: the next step will regard the improvement of the Methodology through its application to different kinds of Mechanical Systems, in order to study further such various useful tools, and at the same time, to implement a data bank which can be helpful for implementing Design for Environment by companies.

6 References

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