

**The Proceedings of the 5th International Conference on
Design and Manufacture for Sustainable Development**
Loughborough - 10-11th July 2007

Home

Welcome

Schedule

Authors

Papers

Welcome to the electronic proceedings of

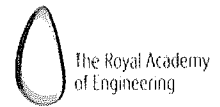
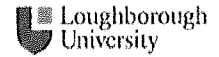
SUSTAIN'07

The 5th International Conference on
Design & Manufacture for Sustainable Development

Loughborough University 10th-11th July 2007

Hosted by the Centre for Sustainable Manufacturing and
Reuse/Recycling Technologies (SMART)

These proceedings are copyrighted © Sustain07



From need to manufacture – the design process in Sustainable Value approach

J ALEXANDRE, J HENRIQUES, J CATARINO, A MAIA, F RODRIGUES, D CAMOCHO

INETI – Instituto Nacional de Engenharia, Tecnologia e Inovação (National Institute for Engineering, Technology and Innovation), Estrada do Paço do Lumiar, 22 - 1649 038 Lisbon, Portugal

ABSTRACT

In a sustainable development paradigm there must be a direct influence and a social responsible relationship between user, designer, and manufacturer. The different stakeholders' interactions should be based on a dynamic influence of their needs. The challenge is to understand those needs, translate and monitor them through life cycle of products or processes. The use of Value Analysis method (namely functional analysis, main phase of that methodology) and its integration with Cleaner Production, allows the development of a methodology that helps the definition of stakeholders needs and their transposition to the design, manufacturing and use phases. Due to the functional approach, without technical solution in the problem definition, this kind of analysis should stimulate the creativity and the innovation.

In this methodology the study subject is defined in terms of functions, quantified with technical, environmental and social criteria, in order to create a true dialogue platform between who orders and the designer, manufacturer or supplier. This approach enables to adjust either the evolution of the different needs and the objectives to be attained. For the development of the work, namely the designer's one it is very important that since the beginning of the study the main objectives and constraints are defined. All this work is made by a multidisciplinary team with people representing the main areas related to the study subject. The methodology allows the quantification of the functional performance (taken into account technical, social and environmental aspects) of a study subject and also all the costs related with materials, water, energy and human resources. The relationship between them will allow to quantify the Sustainable Value. In this paper we present the theoretical structure of the developed methodology and also its main results in several case studies.

INTRODUCTION

Within a market economy that will inevitably reach a breaking point, if the current tendency is kept, it is essential to review the relationship between demand and supply in order to satisfy present needs and protect future ones. Only with more demanding consumers together with more social responsible organisations will it be possible to change market dynamics. Therefore organisations need to change the way they behave – by orienting their management towards Sustainable Development, the way they produce – do more with less environmental and social impacts, the way they inform – in a transparent and responsible way and the way they sell – by offering environmental and social more adequate products. The opinion and needs of the different stakeholders, internal and external ones, can not be neglected in each step of an organisation activity. There must be a direct influence and a social responsible relationship between user, designer, and manufacturer. The different stakeholders' interactions should be based on a dynamic influence of their needs.

Creativity and innovation must be managed in a more demanding way and oriented towards design and development of products, so that functional and technical needs are taken into account together with environmental and social ones. This has not been totally assumed and achieved yet by organisations. It is therefore essential to develop and provide organisations with management methods and tools that help them to implement Sustainable Development concept in their daily activities [Duarte *et al.* 2005]. To achieve it, they must analyse the needs of the different actors along the products' life cycle, so that they can understand them and eventually influence them positively. With this purpose, and trying to apply it to the Portuguese industrial context, a methodology was developed which leads company to create Sustainable Value [Henriques *et al.* 2006]. It will help in the definition of stakeholders needs and their transposition to the design, manufacturing and use phases.

In this context Sustainable Value is the relationship between satisfaction of needs by the study subject and the amount of resources needed to attain it. The methodology here proposed, based on Sustainable Value concept, uses functional analysis, main phase of Value Analysis method [Henriques *et al.* 2003], and its integration with Cleaner Production [Peneda *et al.* 2001]. It allows the quantification of the functional performance (which takes into account economical, social and environmental aspects) of a study subject and also estimates all the costs related with materials, packages, energy, water, labour, equipment, waste, emission, waste water, noise, emissions and waste management and will therefore make possible to measure Sustainable Value.

FROM NEED TO MANUFACTURE

Every organization should be in a dynamic relationship with the client and the product (goods and services) (Fig. 1) and therefore it will try to provide product solutions that better satisfy its clients' needs [Alexandre *et al.* 2006].

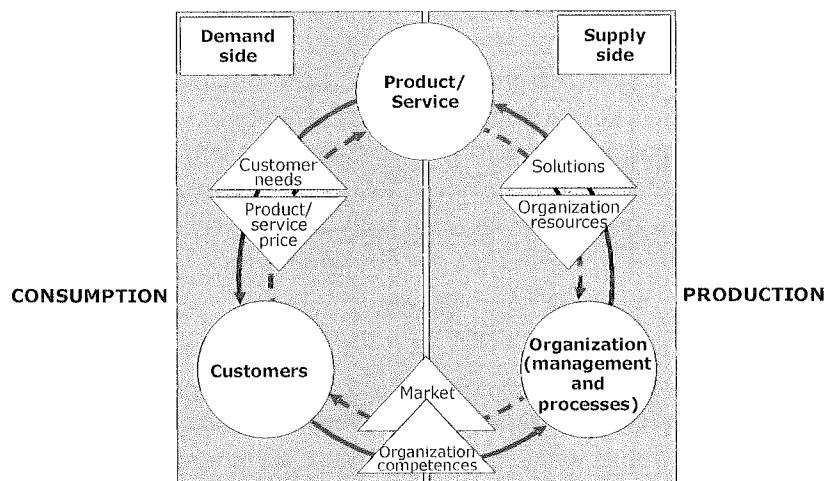


Figure 1, The key elements of demand and supply side

In the process of supplying or reformulating a product in the market two essential aspects must be considered: if the need is not correctly defined the product risks to satisfy in only 50% the user's needs and it is during the conception phase that not only 75% of the product costs are defined but also most of its life cycle impacts. Therefore it is essential to understand how the needs translation can be improved in order to facilitate the process of products conception and production.

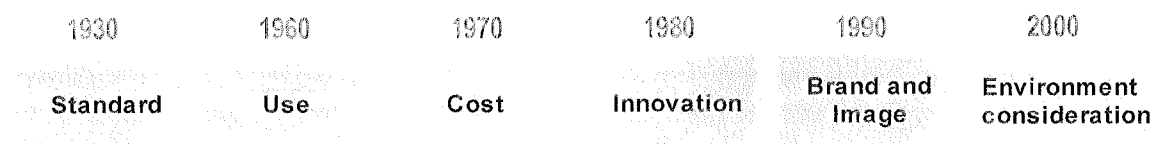
Needs

In order to better understand what is meant by need, the main reasons that lead a client to buy a product (good or service) must be defined. He can do it either to answer to something vital (necessary), or to satisfy a desire (a will that can be suggested or provoked) or to make a dream come true (an illusion difficult to express) [Virely *et al.* 2003].

From the EN1325-1 standard, *need is what is necessary for or desired by the user, a need can be declared or undeclared; it can be an existing one or a potential one.*

The needs of potential clients change because they depend on numerous conditions. Therefore any organisation that wants to evolve must anticipate those needs.

Those variables include technological, social, economic and environmental aspects (Fig. 2). For the last decades different events have contributed to change the reasons that lead to products acquisition: mass production in the 30's, consuming revolution in the 60's, petroleum crisis in the 70's, new markets competition in the 80's, multinationals in the 90's and the sensitisation for environmental impacts in the beginning of this century [Virely *et al.* 2003].



The needs change and so does the reason to buy products

Figure 2, Reasons to buy products

If needs and products evolve, all the related processes and actors must also go along with this evolution.

Functional Analysis

Functional Analysis is the main phase of Value Analysis method and is based on the concept that a product/process (study subject) is evaluated through its performance. User refers to all the elements that interact with study subject (therefore it includes the supplier, producer, distributors, clients, etc.). Functional Analysis – is defined as “*a process that results in a comprehensive description of the functions and their relationships, which may be systematically characterised, classified and evaluated*” [EN 1325-1]. Functional Analysis approach can be oriented towards the reformulation of an existing product or process or to the conception of a new one: Functional Analysis oriented towards the product or to the need. Functional Analysis begins with the identification of functions which translate the needs, and then its characterisation.

In order to facilitate the conversion from needs to functions the study of the way the product interacts with the elements of its environment, along its life cycle, is required. Those interactions will enable to identify the needs of the various elements and to translate them into functions. A useful tool to accomplish this task, graphically, is APTE approach (APplication aux Techniques d'Entreprise) [AFAV 1989], where the different elements that interact with the product are drawn in a graph around the study subject and through the lines representing the actions over the product most of the needs the product must fulfil are identified.

After listing them, functions must be characterised, this comprising two aspects: qualification and quantification. In the qualification the physic phenomenon (actions) over which the product will act or be influenced in order to satisfy consumers, will be expressed in words. The quantification will be done through criteria in order to measure the effect of the product over the physic phenomenon. From a Sustainable Development point a view those criteria

must consider economic, environmental and social aspects which implies taking into account the different stakeholders involved with the study subject.

Due to the functional approach, without technical solution in the problem definition, this kind of analysis should stimulate the creativity and the innovation.

Functional Analysis will enable to question the existence and usability of products and to provide real data that will allow product design managers to verify its tangible (use) and intangible (esteem) components.

Design process

"Design is a creative activity whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life-cycles. Therefore, design is the central factor of innovative humanisation of technologies and the crucial factor of cultural and economic exchange." [ICSID 2007].

In the design process a real problem is analysed and after gathering the necessary information, the solution, which at the moment gives a better answer to it, is searched. It is an iterative process and therefore a final validation is necessary about the accomplishment of the initial aims. In Sustainable Value methodology all the work is developed by a multidisciplinary team with representatives from the different areas related to the study subject. Therefore the presence of a designer is also essential. If Functional Analysis and design phases are compared it will be noticed that the problems have always to do with non satisfied needs that will be characterised by functions (Fig. 3).

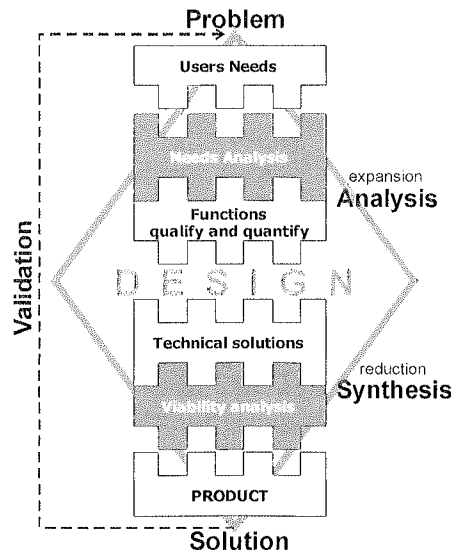


Figure 3, From problem to solution

The next step, after the definition of the problem is to look for solutions. Their economical, technical and environmental viability will be analysed as well as their functional performance therefore allowing choosing the solution with a higher Sustainable Value for the study subject. The design process is part of this approach of analysing problems in order to find solutions. Its importance is mainly evident in the conception of more eco efficient products, once it is during this phase that decisions are taken about its life cycle, from raw materials extraction to production, distribution and use.

The importance of thinking about materials and its origin, processing, application, maintenance, use, recyclability and final deposition, is becoming essential in the design process, being some of these phases of the life cycle the target of specific legislation.

In the design process it is necessary to integrate and balance not only technical and economical elements but also the environmental and social ones in order to induce best practices in production and consumption and to help companies to anticipate environmental and social costs related to products life cycle. The designer is the one that, working in a team, will try to materialise needs and whenever possible induce wishes. He is the manager of tangible and intangible elements.

SUSTAINABLE VALUE APPROACH

The integration of Value Analysis and Cleaner Production led to the Sustainable Value methodology (settled in a manual with the same name developed by the paper's authors) [Catarino *et al.* 2007]. This approach covers the aspects presented above which are centred on the definition of the various stakeholders' needs and on its transfer till production including the design process. The organisation and its products and/or processes are then evaluated through the relationship between their functional performance and the necessary resources to fulfil them, which means their Sustainable Value.

Data is gathered, analysed and supplied in order to help top management decisions. The methodology is divided into eight phases:

1. The company general data; 2. The project specific data; 3. Global inventory; 4. Functional Analysis; 5. Problems synthesis; 6. Ideas identification and previous evaluation; 7. Viability analysis; 8. Action plan.

During the two first phases real data about the organisation profile, the objectives to be attained with the project, as well as the definition of the working team and the study subject is gathered. In the global inventory the input and output data of the process is defined and quantified (labour conditions, materials, packages, water, energy, products, waste, emissions and noise).

It is during Function Analysis phase that the product or process will be seen in a different way by questioning whom will it suit, which it its objective and what will interact with. It is by analysing the answer to those three questions that needs will be characterised and translated into functions, those being characterised by criteria and quantified by levels. Companies will define the most adequate criteria to characterise the functions of the study subject. Those criteria must take into account the three elements of Sustainability.

Some of the possible criteria to be considered are presented as an example. It is not an exhaustive list as the specificity of each study subject and its functions will imply different criteria:

- non conformities (parts, air, noise, emissions, etc);
- quantities (operations, products, auxiliary materials, danger materials, waste, etc);
- quantity of energy used;
- renewable energy (%);
- reused water;
- clients satisfaction;
- materials complexity;
- recycling potential;
- level of professional training;
- number of handicap employees.

In every case study developed until now, Sustainable Value of the study subject has been estimated through the weighted sum of every function over the cost of the involved resources.

But the gathering and treatment of information allows more precise analysis, such as the estimation of Value for each function which will allow, for example, the company to make a comparison between study subjects having a function in common (Fig. 4).

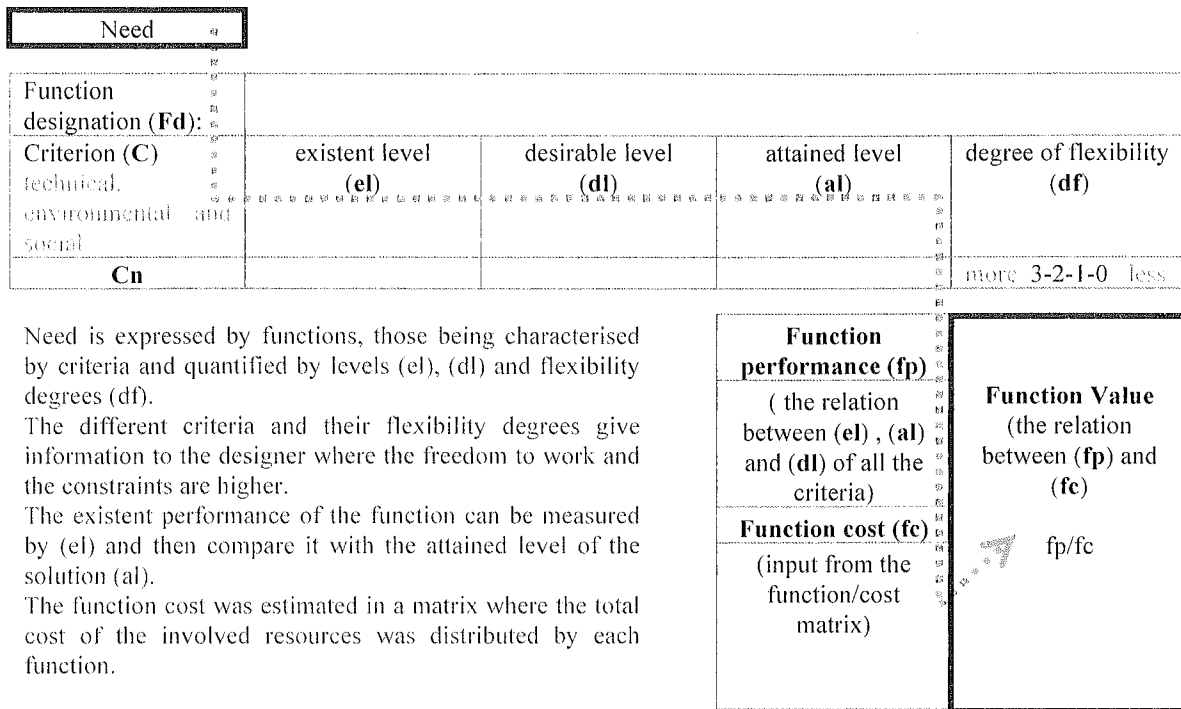


Figure 4, From need to Value

After Functional Analysis a synthesis of the detected problems at functional, environmental social and economical level, is made. This synthesis will enable the working team (where the designer is included) to become aware of some of the main aspects (problems) to be faced during ideas generation for improvement. The viability of implementation of the ideas generated is then evaluated leading to the preparation of an action plan. The aim of the application of Sustainable Value methodology within an organisation can be the analysis of either a manufacturing process (or part of it), or an existing or non existing product. When it is an existing one the analysis of the associated process will also be made.

PILOT PROJECT

DEUSA project was pioneer in the application of Sustainable Value methodology. Seven companies from Aveiro region, mainly from metal mechanics sector were involved. There were various study subjects and the methodology was applied either to processes or products and their processes (wheel for tubeless tyre, wood stove, solar panel and oil stick process).

One of the main objectives of the Project was the promotion of companies Eco-efficiency through the implementation of preventive management strategies and tools:

Cleaner Production: to do more with a higher quality with less materials, energy, water and pollution;

Value Analysis: to evaluate the effect of performance improvement (economical, environmental and social) of the product and/or process in creating more Value for the company.

This kind of application intended to raise the opportunities of increasing Sustainable Value of companies and their products; to develop new competences in order to create more responsible organisations and to promote a demonstration effect.

Work within companies was implemented by applying Sustainable Value manual phases. Together with the application several working meetings took place within the enterprise, thematic workshops were accomplished and information was exchanged through an informatics platform. This project allowed validating the Sustainable Value methodology and its applicability to different study subjects. For all of them an increase of Sustainable Value was attained (Fig. 5).

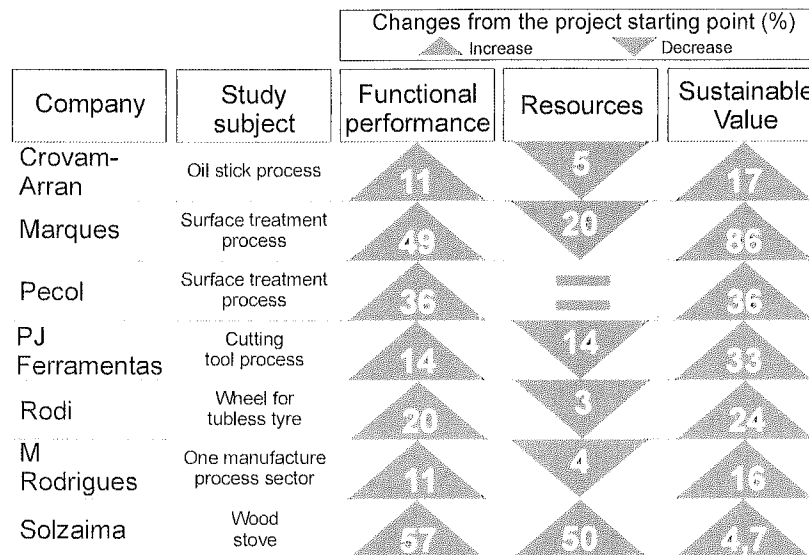


Figure 5, Value results in DEUSA Project

For the companies where the study subject was the reformulation of a product, designers participated, since the beginning, in the working team. This allowed them to get a detailed briefing of the problem and to contribute in a more effective way to the definition of more sustainable solutions for the product and its process.

Main results

With the adopted methodology, the project enabled the companies involved to obtain results in different aspects, beyond increasing their Sustainable Value at:

information level:

- environmental diagnosis for the production process; costs identification and reduction and improvement of internal communication;

environmental aspects:

- consumption reduction in what concerns materials, energy and water; preventive approach to waste and reduction of toxic dispersion;

strategic management:

- organisation eco-efficiency improvement; organisation competitiveness improvement; adoption by the enterprise of a socially more responsible behaviour and Sustainable Value increase;

and at conception level:

- improvement in the definition of clients' needs and of the objectives to be attained in the development of new products as well as in monitoring their functional development.

The application of the methodology also leads to the adoption of more Corporate Social Responsible behaviour by the companies as well as to the increase of their competitiveness. It shows a high potential to be used as an operational tool for the development of sustainability at entrepreneurial level.

CONCLUSIONS

Sustainable Value methodology enables not only to inquire stakeholders' needs and measure its satisfaction through specific metrics but also to sensitise those stakeholders for Sustainable Development requirements. It is an iterative process that allows adjusting the characterisation of those needs according to their evolution. The elements that interact with the study subject along its life cycle have therefore a dialogue platform with well defined criteria that enable to validate its objectives.

The work developed by a multidisciplinary team allows knowledge sharing and adoption of eco efficiency concept, changing behaviours and opening participants' minds to ecodesign and design for sustainability questions. With this approach design process is easier because the study subject is analysed through different points of view, thus allowing identifying and characterising the needs / problems. Data is gathered in a form (problems synthesis) where the identified problems are listed, this being the starting point for the development of ideas to improve the sustainable profile of the study subject.

Design will be an important tool and could be used to change the market centred products into product service systems. However, to achieve this it is necessary to change mentalities. Only with more demanding clients, informed and sensitised to Sustainable Development needs, the tendency will change towards "demanding influencing supplying".

This will imply changes in organisations functioning, requiring a systemic approach to problems and net working (cooperation). It is essential to operationalize Sustainable Development, through products and processes optimisation. For this purpose it is necessary to involve the potentialities of existing methodologies and to develop new ones profiting from the synergies and complementarities between them.

The development and application of Sustainable Value methodology as a result of different approaches (functional analysis, pollution prevention, eco-efficiency, eco-design, life cycle thinking) took advantage of their synergies and complementarities. The output of this work was the improvement of the companies Sustainable Value, translated into the increase of processes and products performance in the three main areas of Sustainable Development.

The Design process becomes more accurate, due to a better definition and control of stakeholders' needs. Nowadays, those needs must include intangible, environmental and social aspects. This methodology allows collecting the main information and searching the solutions that better satisfy them in order to achieve more sustainable products and processes.

REFERENCES

- AFAV – Association Française pour l'Analyse de la Valeur, 1989. *Exprimer le Besoin – Applications de la demarche fonctionelle*. AFNOR Gestion.
- ALEXANDRE, J., CAMOCHO, D., CATARINO, J., HENRIQUES, J., MAIA, A., 2006, *How can Design, Value Management and Cleaner Production work together?*,

- communication presented at 2nd International Conference on Quantified Eco-Efficiency Analysis for Sustainability, Egmond aan Zee, Netherland
- CATARINO, J. HENRIQUES, J., MAIA, A., ALEXANDRE, J., RODRIGUES, F., CAMOCHO, D., 2007, *Manual Valor Sustentável (Sustainable Value manual)*, INETI, 1st edition
- DUARTE, P., MARTINS, P., ALEXANDRE, J., 2005, *Pró-active behaviour induction by integration of sustainability in business strategic management - INOVE Project Case Study*, 10th European Roundtable on Sustainable Consumption and Production, Belgium
- European Standard EN 1325 – 1 (2001) – *Value Management, Value analysis, Functional Analysis vocabulary - Part 1: Value analysis and Functional Analysis*
- HENRIQUES J., ALEXANDRE J., CATARINO J., MAIA A., 2006, *Sustainable Value*, communication presented at 1st ICEC & IPMA Lobar Congress on Project Management Ljubljana, Slovenia
- HENRIQUES, J., ALEXANDRE, J., PENEDA, C., 2003. *Manual Análise do Valor orientada para a Sustentabilidade (Value Analysis oriented towards Sustainability)*, Cadernos do INETI, 1st edition
- ICSID – *International Council of Societies of Industrial Design*, www.icsid.org, January 2007
- PENEDA, C., et al, 2001. *Manual PREPOL – Prevenção/Minimização da Poluição nas Empresas (Pollution prevention/minimization in companies)*, Cadernos do INETI, 3rd edition
- VIRELY, J.M., et al 2003 - *L'Analyse Fonctionnelle (Functional Analysis)*, ENS Cachan, www.si.ens-cachan.fr, January 2007

BIBLIOGRAPHY

- ALEXANDRE J., HENRIQUES J., CATARINO J., MAIA A., RODRIGUES F., CAMOCHO D., 2006, *How to measure Value from a sustainable point of view*, Conference “Delivering Value Today & Tomorrow, Brighton, UK
- ALEXANDRE, J., 2002, Master thesis in Materials Management and Quality : *Contributo da Gestão pelo Valor e do Design Industrial na concepção de produtos (Contribution of Value Management and Industrial Design in products development)*, 2002, FCT/UNL- Faculty of Sciences and Technology, New University of Lisbon
- European Standard EN 12973 (2003) – *Value Management*
- FRAZÃO R., PENEDA C., FERNANDES R., 2006, *Adoptar a perspectiva de ciclo de vida (Adopt life cycle view)*, Cadernos do INETI, 2nd edition
- MANZINI, E., INDACO, 2006, *Design for sustainability - How to design sustainable solutions*, Politecnico di Milano,

THE AUTHORS

Jorge Alexandre MsC, Industrial Designer

Jorge currently holds a position as researcher at INETI/CENDES (National Institute of Engineering and Innovation/Centre for Sustainable Business Development, Lisbon). He has been working for the last fifteen years the synergy between Value Management / Value Analysis and Industrial Design and more recently with Sustainability Development tools.

Phone +351 21 0924797 Email jorge.alexandre@ineti.pt

João Henriques MBA, Mechanical Eng.

João is an engineer working for the last twenty years in Value Management / Value Analysis, Portuguese delegate in the EGB and in the CEN/TC 279, member of the Board of Directors of APAV in Portugal. He is a researcher at INETI in the Centre for Sustainable Business Development.

Phone +351 21 0924797 Email joao.henriques@ineti.pt

Justina Catarino, PhD Environmental Engineer

Justina is an engineer working for the last years in Cleaner Production, eco-efficiency and sustainability in companies. She is a researcher at INETI in Sustainable Development Department.

Phone +351 21 0924600 Email justina.catarino@ineti.pt

Anabela Maia, Postgraduation on Environmental Management and Policies

Anabela is Technician at INETI/CENDES (National Institute of Engineering and Innovation/Centre for Sustainable Business Development, Lisbon), working for the last twelve years in environmental management, cleaner production, eco-efficiency and sustainability in companies.

Phone +351 21 0924600 Email anabela.nogueira@ineti.pt

Fátima Rodrigues, Agronomic Eng.

She is an engineer working for the last fifteen years in Environmental Management and more recently with Sustainable Development tools. She is a senior researcher at INETI in the Sustainable Development Department.

Phone +351 21 0924600/01 Email fatima.rodrigues@ineti.pt

David Camocho, Industrial Designer

David is an industrial designer, working for the last five years at INETI/CENDES (National Institute of Engineering and Innovation/Centre for Sustainable Business Development, Lisbon). He has been working in several projects in the area of Ecodesign and Sustainability.

Phone +351 21 0924797 Email david.camocho@ineti.pt