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ARE DESIGNERS FULLY EQUIPPED TO SUCCEED WITH NEW ENVIRONMENTAL REQUIREMENTS?.

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Abstract

This paper discusses that current and expected European Environmental Regulation (ER), such as EoLV, IPPC, IPP, WEEE, etc., is passing to industry more responsibility to drive market towards sustainability. European and Spanish environmental regulation is analysed from three points of view: the type of contamination considered, the industrial sector affected and the product life cycle stage (LCS) it is intended for. The analysis has been approached adopting a product engineer view, assessing how ER influences design activity.

Most of ER is of the Command and Control type. Economic Instruments, Green Procurement and Voluntary Agreements are still of little significance. Production and Raw Material are the LCS more loaded with ER. Little ER affects Use and Retire LCS although they will get more burdened in the near future. Distribution is not considered in ER, neither it will be considered in the short term.

Parallel to that, it has been analysed current ecodesign tools. This research concludes that these tools are adequate for current design environmental requirements. However, future environmental requirements will force product designers to endeavour new activities such as environmental policy determination, company's functional integration, team working with product stakeholders, etc. There is still a need to develop tools that allow processing environmental specifications when fulfilling these activities.

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Keywords: Environmental Regulation, Ecodesign tools, Success Factors for Sustainable Production

1. Introduction.

Openly, European Commission (EC) is increasingly transferring to industry the responsibility of taking care of environment. And it carries out it with more or less impulse depending on the economical and political possibilities, but never stepping back. Therefore, among the so called *Success Factors* (SF) for industry effectively contributing to sustainable development, Government Intervention is one of the leading.

In this paper SF are those attitudes, capabilities, or opportunities at industry reach that

[1] "*Programa de Incentivo a la Investigación de la UPV*" (PPI-05-02 & PPI-03-03). Technical University of Valencia.

remarkably help to achieve the objective of sustainable production. Success Factors (SF) are various and have been studied by several authors [1], [2], [3]. According to these, SF can be classified as shown in the following table.

Table 1. Success Factors for sustainable Production. Adapted from [1], [2] and [3].

SUCCESS FACTORS	INTERNAL FACTORS	Consciousness, favourable attitude towards environment.
		Benefit, company development
		Investment and risk. Innovation policy.
		Workplace health and safety
		Functional integration (across departments)
		Staff involvement and training
		Compliance with legislation
		Stakeholder relations. Participation in other policy measures.
		Commitment with community. Action for external environment.
	EXTERNAL	Competence improvement or consumers demand. Market trends
		Government intervention
		Resources scarcity, rise of prices.
		Technology innovation

SF are not independent and often, given a certain environmentally-sounded improvement, it is not easy to analyse separately the cause-effect relationships with the several SF involved. Yet, always among those involved SF, producers identify government intervention as one of the most influential. This paper analyses this SF.

2. Government intervention. Environmental Regulation.

In order to help industry to protect environment, Environmental Regulation (ER) can be classified into five approaches [4], [5], namely, from more involvement to less: *Command and Control*, *Economic Instruments*, *Green Procurement*, *Support* and *Inaction* (but protecting some specially valuable areas or living beings).

It could be said that, since the *Earth Day 1970*, most of early ER was of the *pollution control* approach dealing with the abatement and clean up of pollution. According to Hilton [1], much of this early regulation led to important expenditure by industry and the view that environmental improvement was associated with costs rather than benefits.

The first data claming that little improvement was being accomplished, and the results of the preparatory works for Rio'92 summit, introduced in EU key principles like *polluter pays, precautionary* and *preventive action*. Thus, in the late 1980s and the 1990s ER moved to prevention and integration, starting to address *ecoefficiency* and *ecodesign* at a comparable level to *end of pipe* control (IPPC'96, Packaging Regulation, End of Life Vehicles).

Currently, the *extended responsibility* principle has been observed in the proposals for a directive on *environmental liability*, and it is present in the *Waste Electrical and Electronics*

Equipment Directive draft (WEEE), among others. Besides, in parallel, economic instruments, green procurement and several support schemes are becoming to be applied to promote a green market, in which greener products and services will not necessarily be more expensive [3], [6].

Therefore, at the beginning product/production engineers had to improve their company performance so as to accomplish legal requirements, innovation seldom necessary, and environmental features were not a competitive key. If new ER succeeds, and the other SF develop as expected (SF are intricately linked, and they can not guarantee success by their own), industries will tackle a new challenge: *the greener the better*.

Industries will have to cope not only with maintaining or improving quality, price, lead time, and flexibility but they will have to decrease the product life cycle environmental burden, collect and provide environmental performance information, participate in product panels with all stakeholders, and envisage and minimise social and environmental risks.

3. Environmental Requirements.

3.1. Environmental requirements from current regulations

European Environmental Regulation has been analysed as well as Spanish [6], [7], [8], [9]. Although ER change very much through the European regions (and Spain is well behind front-runners countries like Sweden, Denmark, Holland, Germany, UK, etc.) and over the world, authors think this study is of interest for every product engineer. On the one hand, European Commission is working to homogenise all state members ER (even if only at a certain level), on the other hand, this study has put much interest in future ER, likely to develop likewise in every industrialised country [7].

In this paper three issues are analysed: *Contamination*, *Life Cycle Stage* and *Industrial Sector* (the full research results can be found in [10]). *Resources depletion* has been included within *Contamination* according to the advice of many authors (see for example [5], [8], [11]) and it refers to the consumption of non-renewable resources, or to renewable resources consumed at a rate higher than its reposition rate. Thus, resources depletion means decreasing the available natural capital for future generations.

Life Cycle Stages (LCS) refers to the product/service LCS the environmental regulation studied seems to focus on. For example, there are directives like EoLV that clearly focus on *Retire*. Besides, EoLV will also affect the materials automobiles are made of, the way they are designed and produced, and even the way they are used. But EoLV does not really consider the environmental impact of these latter stages. Then, EoLV should be classified as a directive intended to diminish the environmental burden at product *Retire*.

Finally, it was analysed whether every particular ER is intended for a specific Industrial Sector (IS) or generally applicable. In this paper we just consider the IS most frequently reflected in engineering design papers. These are: Electric equipment & metal components, Electronic equipment, Wood & furniture, Automobile and Other Internal-Combustion Machines (ICM). With this 20% of industrial sectors, 80% of engineering design activities are covered (only product/service design considered) [3], [12], [13]. All this information is collected and shown in the following matrix:

Table 2. Current environmental regulations pressure over certain industrial sectors.

		Raw Materials		Production		Distribution		Use		Retire	
		Europe	Spain	Europe	Spain	Europe	Spain	Europe	Spain	Europe	Spain
AUTOMOBILE	Atmsp. Emissions	Light	Light	Light	Medium	None	None	Medium	Medium	None	None
	Spill	Light	Medium	Light	Medium	None	None	None	None	None	None
	Waste	Light	Light	Light	Light	None	None	Light	Light	Light	Light
	Toxic waste	Medium	Medium	Medium	High	None	None	Light	Medium	None	None
	Noise/Vibrations	None	None	Light	Light	None	None	Light	None	None	None
	Resrcs. Depletion	None	None	None	None	None	None	None	None	None	None
OTHER COMB.-INT MACHINES	Atmsp. emissions	Light	Light	Light	Medium	None	None	Medium	Medium	None	None
	Spill	Light	Medium	Light	Medium	None	None	None	None	None	None
	Waste	Light	Light	Light	Light	None	None	Light	Light	None	None
	Toxic waste	Medium	Medium	Medium	High	None	None	Light	Light	None	None
	Noise/Vibrations	None	None	Light	Light	None	None	Light	None	None	None
	Resrcs. depletion	None	None	None	None	None	None	None	None	None	None
ELECTRIC EQP. & METAL COMPS.	Atmsp. emissions	Light	Light	Light	Medium	None	None	Light	Light	None	None
	Spill	Light	Medium	Light	Medium	None	None	None	None	None	None
	Waste	Light	Light	Light	Light	None	None	Light	Light	None	None
	Toxic waste	Medium	Medium	Medium	High	None	None	Light	Light	Light	Medium
	Noise/Vibrations	None	None	Light	Light	None	None	None	Medium	None	None
	Resrcs. depletion	None	None	None	None	None	None	None	Light	None	None
WOOD & FURNITURE	Atmsp. emissions	None	None	Light	Medium	None	None	Light	Light	None	None
	Spill	Light	Medium	Light	Medium	None	None	None	None	None	None
	Waste	Light	Light	Light	Light	None	None	Light	Light	None	None
	Toxic waste	Medium	Light	Medium	High	None	None	None	None	None	None
	Noise/Vibrations	None	None	Light	Light	None	None	None	None	None	None
	Resrcs. Depletion	None	None	None	None	None	None	None	None	None	None
ELECTRONIC EQUIPMENT	Atmsp. Emissions	Light	Light	Light	Medium	None	None	Light	Light	None	None
	Spill	Light	Medium	Light	Medium	None	None	None	None	None	None
	Waste	Light	Light	Light	Light	None	None	Light	Light	None	None
	Toxic waste	Medium	Medium	Medium	High	None	None	None	None	None	None
	Noise/Vibrations	None	None	Light	Light	None	None	None	Light	None	None
	Resrcs. Depletion	None	None	None	None	None	None	None	None	None	None

Key: None Light Medium High

3.2. Environmental requirements from expected regulations

In the last five years, numerous draft Directives have been proposed and discussed concerning the relationship between industry activity and the environment [6], [7]. Although arguments between EC and industry representatives are some times *intense*, it can be envisaged a clear increase in ER pressure. Again, most of the new ER will be of the *command and control* type. In spite of very interesting approaches like the *Integrated Product Policy* [14], one could say still EC fall to forget the potential positive effects of other types of ER like green procurement, environmental taxes, etc.

From qualitative researches on the draft environmental Directives, carried out by [7], [10], [15], [16], the following conclusions can be taken out:

- Among all life cycle stages, *Use* and *Retire* are affected by most of the new environmental requirements. *Production* is also much influenced. Therefore, an important increase on environmental requirements for these LCS is expected in the near future.
- Particularly electric and electronic equipment are the industrial sectors most affected. Energy efficiency (use) and recycling (retire) will be the main requirements.
- Also hazardous substances and packaging waste will be more loaded by requirements.
- Ecodesign is becoming explicitly promoted among industry activities. There is a clear shift towards pollution prevention and eco-innovation which also means more complex requirements (product take back, public life cycle environmental information, etc.).
- New Directives seem to consider that each industry can not solve its environmental problem alone and are promoting *product panels* involving all product chain stakeholders.
- There are also new Directives intended to promote a greater demand of environmentally sounded products through better information, lower prices and administration greater demand. But these Directives seem to be less supported.

Anyhow, still the majority of the ecodesign choices are let to the company/designer sensibility or competitive choice. There is very little regulation envisaged about issues like resources consumption (even considering energy efficiency support) or environmentally conscious distribution. For example, selling products to distant markets can produce a noticeable environmental damage due to transport (particularly if sent by plane). This is well known, and transport is responsible for 30% to 50% of air contamination in Europe [8]. Nevertheless, there exists only ER applied to the product carriers (truck, train, plane, etc.). Designer does not have to accomplish any regulation when choosing a carrier, no matter where the market is.

ER concerning toxic waste and spills is devoted to the *Production* life cycle stage, and secondary to *raw materials* LCS. But they are much less devoted to *Distribution*, *Use* or *Retire* LCS. It is up to the designer to consider this ER or not when designing these product LCS.

3.3. Discussion

The analysis is both quantitative and qualitative. Not only the amount of ER concerning one topic has been taken into consideration, but the type, scope and austerity of that ER. Besides, only direct influence has been taken into consideration in the table. For example, there is ER about atmospheric emissions of trucks. This ER affects directly the *Use* life cycle stage of trucks (*other combustion-internal machines*) and indirectly the *Distribution* LCS of every product carried by truck. Only the first effect has been considered because it does affect truck designers' decisions.

In every industrial sector, assembly plants have been considered but not suppliers. For example, in automobile IS, tyre suppliers, windows suppliers, etc. are not considered. It is assumed that most of the design activities are carried out in assembly plants (including materials selection and specifications). Therefore they are the main responsible for the final product environmental burden along its life cycle. On the other hand, some industrial sectors like toys, for example, have been considered either within electric equipment, electronic equipment or wood.

It has been considered that packaging is another component of a product. Then, a packaged product produces an environmental damage when unpacked, and that happens at the beginning of its *Use* LCS. Secondary, packaging produces an environmental impact during *Production* due to energy consumption and waste generation; and in *Raw Material*, as it is another product component.

There is ER like the eco-labelling scheme [17], or the LIFE-Environment program [18], which affect all the life cycle stages for all the contaminants, but none of them in particular. Because of that characteristic, they have been considered in the research but they do not appear in the table.

In table 2 it is clear that *Production* is the life cycle stage most influenced by ER. Also ER tries to diminish *raw Materials* environmental burden by affecting its selection for production. Product *Use* is not very loaded with ER, the product *Retire* is even less loaded, and, as mentioned, almost no ER has been found to diminish the environmental burden of the product *Distribution.*

The contaminant most regulated is toxic waste, almost completely by means of *command and control* ER. There is not much regulation about noise & vibrations and solid waste, and almost none about resources consumption efficiency. To this respect, it is said that if some of the taxes on labour moved to raw materials, recycling would be less expensive relatively [16]. Recycling is labour intensive, so the less taxes over labour and the more taxes over resources, the more competitive it becomes.

There is a need for different ER. There are already numerous *command and control* ER but it is still ineffective since it is regarded as an imposition. Economic instruments such as taxes or funds, voluntary agreement schemes, green procurement, etc. are the necessary complement to *command and control* ER [19].

Apart from quantitative, there are some qualitative differences between current ER pressure over industries and foreseen pressure, particularly concerning *Retire* and *Use* life cycle stages. New directives (still draft) like Waste Electric and Electronic Equipment, Extended Liability, Energy Efficiency Requirements for End Use Equipment, etc., are going to force product engineers to solve new environmental problems that extend beyond a single company's limits.

4. Available tools for product designers.

Accomplishing new environmental regulation is a challenge industry will address to the design function. It is well known that, among all company functions (management, purchase, sell, production, etc.), the design/engineering function is responsible of, roughly, 70% of final product characteristics (costs, quality, environmental burden, etc.) [20]. The awareness of that has led to an increasing amount of design tools and, more recently, to numerous ecodesign tools.

Firstly, ecotools were mainly focused on the optimisation of the existent product/production line (coherently with the compliance of environmental restrictions). Lately, ecotools are arising focused on innovation and activities to better compete in greening production. As *eco-transformation* is not yet urgent, one could say that designers are full equipped to overcome the current requirements. But, do they have the adequate tools for future foreseeable environmental requirements?.

To study and classify ecodesign tools in order to look for gaps or inadequacies is a very complex task, starting by the fact that many structured knowledge forms lay within the ill defined concept of *tool*. However, every such a research has yielded meaningful results [10], [11], [12], [21]. According to these, the following table shows tools that can be used for product ecodesigner activities.

Table 3. Tools for product ecodesigner activities.

PRODUCT ENGINEERING ACTIVITY	REVIEWED AVAILABLE TECHNIQUES
Environmental Policy and Production Strategies	Forecast and Backcast. Strategy charts. Ecoefficiency and sustainable indexes (ESI). ISO 14001/EMAS guidelines. Handbooks
Driving Forces Assessment and Environmental Accounting	Check Lists. Life Cycle Costing (LCC). ESI. ABC Costing. Willingness To Pay (WTP). Outsourcing. End-of-Life Design Advisor (ELDA). Environmental Value Chain Analysis (EVCA).
Environmental, Societal and Ethical Impact Assessment	Environmental Impact Assessment (EIA). Check Lists. LCA. Environmental Risk Assessment (ERA). Outsourcing. Life Cycle DataBases (LCDB).
Objectives and Goals Statement. Metrics selection	Check Lists. Web diagrams. Value-Environment Analysis (VEA). Internal Norms. LCA. Ecodesign tools. LCC. ESI. Eco FEMA. Handbooks. ISO 14031. Utility Functions. QEFD. LCDB
Design activities planning and tools selection	Decision Aid Techniques (DAT). Planning tools. Ecodesign guidelines. Method-Mix technique. QEFD. Handbooks. Life Cycle Planning
Internal/External Support. Functional Integration	QEFD. ISO 14001/EMAS Guidelines. Life Cycle Planning
Solution Synthesis and Realisation	Expert Rules. Internal Norms. Ecodesign. Creativity techniques. CAD. End-of-Pipe technology selection techniques. DfX. VDI2243. Outsourcing. Life Cycle Planning. Design for Modularity. Design For Recycling/Reuse/Remanufacturing.
New Product/Service Assessment. Feedback	Check Lists. Web Diagrams. DAT. Internal Norms. LCA. LCC. ERA. EIA. ABC costing. Outsourcing. Utility Functions. ELDA. EVCA
Marketing	Green Marketing. WTP. e-Commerce. Environmental Declarations. Ecolabelling,
Contribution to company’s improvement	DAT. ESI. ISO 14001/EMAS

Figures 1 and 2 show a comparison among all activities studied in table 3 for both product eco-redesign and eco-innovation. The web diagrams have 10 axes, one for every kind of activity a product engineer is envisaged to do. Axes are divided into 4 levels measuring the techniques availability for product environmental improvement. Level 0, in the centre means *none*, level 1 *some*, level 2 *quite*, level 3 *adequate* and level 4 *abundance.* None of the levels should be understood as absolute judgements, they are general opinions based on the above mentioned researches [11], [12], [21] and authors' [10].

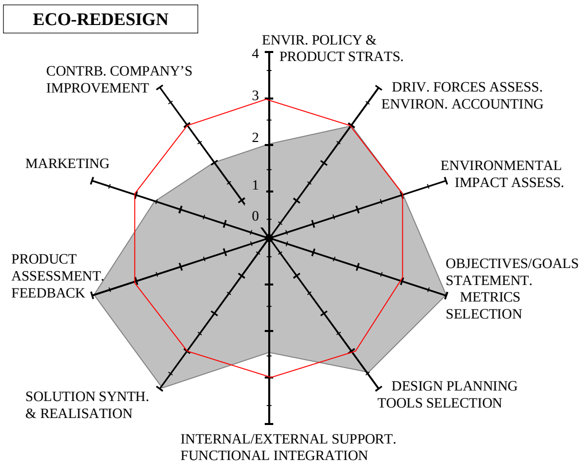

Figure 1. Tools available for eco-redesign

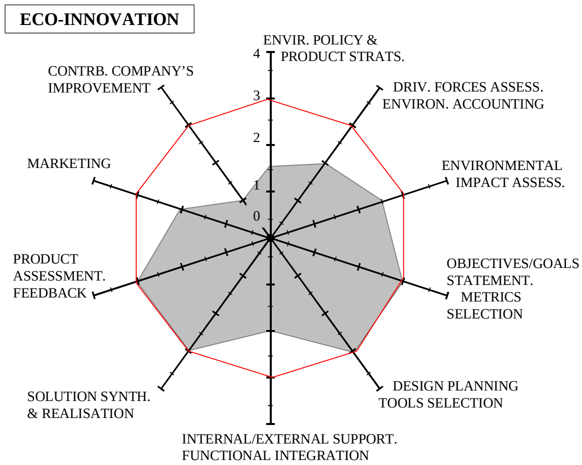

Figure 2. Tools available for eco-innovation

For activities such as environmental assessment, environmental accounting, objectives statement, metrics selection, design planning, creative solution synthesis and solution viability analysis, that could be named *traditional*, designers are using a wide set of tools (specific and holistic). Hence, it seems that designer are *well equipped* for these activities, except for the claim that tools are not tailored for a specific company and, sometimes, designers have to adapt to them or change them [10], [21], [22], [23].

Still, in order to make production sustainable, solutions beyond eco-redesign are needed. Many authors do recommend to endeavour product eco-redesigns, of likely and short term benefits, in parallel with product eco-innovation, riskier, medium term intended but potentially more profitable [11].

Real eco-innovation, apart from exceptions, will occur when industry crosses its boundaries in search for co-operation with stakeholders. Then, designers should have to help in activities like defining the company's environmental policy, introducing environmental costs into company accounting, analysing and considering environmental driving forces, looking for internal and external support for larger and riskier projects and assessing new product contribution to better company environmental performance. It has been found little literature about specific ecodesign tools in these new activities.

6. Conclusions.

One of the first and main conclusions of this research is the fact that, generally speaking, success factors are still away from being significant. There is still much work to do for industry to feel that sustainable production gives more benefits than traditional production. Currently, environmental regulation is said to be the main driver when designing to diminish the environmental burden of the product life cycle. This research has shown that ER pressure is rather *tolerable* for most of the companies, even with the new directives envisaged (that will increase pressure over some companies). Therefore, for a real transformation to occur, the concurrence of different SF is essential, both internal (staff training and sensibility, innovation policies, functional integration, etc.) and external (market demand, technology innovation, etc.).

Saying ER pressure is tolerable does not mean designers are not meeting an increasingly intricate challenge. With the help of the new design tools, product engineers are, generally speaking, adequately equipped to give solution to the current environmental requirements. But, to the authors feeling, environmental pressure is changing quickly. Companies, except for front-runners, are not getting ready for the envisaged scenario where materials cycle are almost closed, efficiency is a market demand, eco-labels differentiate environmentally conscious products from others, etc.

This lack of adaptation is due, among other negative factors, to the lack of well proven and available tools to integrate environment into activities like working concurrently with stakeholders, company functional integration, forecasting, public policy involvement, etc. Product ecodesigners will need to participate in all these activities to better process information in the form of product specifications.

New eco-tools will come soon after companies integrate functions across departments, start medium-term eco-innovation programs parallel to short-term eco-redesign programs and get involved with stakeholders in product panels and voluntary agreements.

In the past, aiming to improve quality, flexibility or cost, product engineers have been able to work with stakeholders, to arrange multidisciplinary teams and to get involved in public policies. Therefore, there is an available valuable experience to be used for the new environmental objectives. Tools should not be too difficult to adapt to fulfilling environmental objectives, neither should they be too difficult to be created if necessary.

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