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TOWARD UNIFIED ENVIRONMENTAL ACTIVITIES IN ENTERPRISE

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1. Introduction

The organization today must respond to an increasing rate of environmental challenges. At first, the industry should respect the legislative regulations which demand the "ecologically necessary", a set of minimum environmental requirements [Manzini]. These regulations focus on either the performance of offers (such as ERP, RoHS, and WEEE etc.) or the daily activities of enterprise. (Ex: local anti-pollution standards and WEEE - recycling framework, etc.) The second, with the "sustainable development" concept being gradually understood and accepted by the public, implies the growing diversity of the green requirements to improve human's "life quality". These requirements take attention into two categories, "green product by eco design" (some surveys show that more than a third of US consumers are willing to pay more for eco-friendly products, and in other countries, such as in China, this is even higher) and "green company" (Ex: 44% of UK consumers want more information on what companies are doing to be green) [WRI 2010].
Till now, to answer these above requirements, the "eco design" concept had been focused on to contribute to the corporate environmental improvement. The large number of available eco design methods and tools leads to a grand challenge: how to identify the suitable eco methods. "Design", as one of corporate core activities, should coordinate with other corporate functions to implement the daily acts. This paper, analyzes and classifies some environmental improvement activities (named as "Eco activities" below) in different corporate functions (eco design, eco purchasing, eco manufacturing, and eco communication), to expatiate that the suitable identification of the "eco design" methods and tools should not only consider the technical targets and the related criteria, It has also to consider the coherence with other parallel executing eco design methods and the coherence with eco activities of other corporate functions. Finally, this paper proposes a systematic model, which treats about the relationships among different eco activities and related methods on global level. This framework needs to be developed to support the selection of suitable eco design methods.

2. Eco activities in enterprise

2.1 Eco-engineering

Eco-design is an approach that takes into account environmental impacts in the design and product development and integrates environmental aspects throughout its life cycle (raw material, at the end of life, from manufacturing, logistics, distribution and use). After 20 years of development, we see many of the major steps of ecological design. According to the analysis of methods and tools, the eco design approaches are classified by three main categories: [Brezet and Van Hemel 1997], [Reyes 2009] and [Hallstedt et al. 2010]

- *Partial eco design*: the environment has been considered as a new "constraint" for the product. The eco design activities modify and improve the product by certain environmental indicators

(the energy consumption of final product, the recycling rate of components and the GHG emission during the manufacturing phase, etc.). To identify and track these changes, environmental requirements are noted into the specifications of the product. The typical methods and tools of this area are "DfX" series, for example, "Design for recycling", "Design for disassembly" and the regulation compliant tools.

- *Classic eco design*: the environment has been considered as a new "criterion" during the design phase. This type of eco design activities considers the entire life cycle of the product from a multi-criteria perspective. According to this global view, eco design improves the environmental impacts and avoids the transfer of impacts to other phases of life cycle of product. In this area, we find a series of LCA and LCA-related tools, such as simplified LCA, LCA-based metrics and LCA in combination with economic tools. [Baumann et al. 2002], [Hur et al. 2005].
- *Innovative eco design*: the environment has been considered as a new "value" for the product. The improvement of environmental impacts has been focused on as a "key" of development for the product and the enterprise. The innovative eco design does not analyze the used components and materials, nor the entire product; it creates and develops the new service, functionality and concepts of offers which bring some positive influence on environment [Reyes 2009]. "Sustainable product Design" is an example of the eco-tools for this area.

To contribute to each eco activities in the area mentioned above, a vast range of methods, tools and concepts have been developed [Brezet and Van Hemel 1997], [Unger et al. 2008], [Baumann et al. 2002], [Siegenthaler et al. 2005] and [Hallstedt et al. 2010]. Even for a same environmental topic, according to different characteristics of each eco method or tool, such as the output nature, the main function, the working manners and quality of inputs, these methods require different inputs, related-to competences and information system. The methods and factors to integrate the environmental aspects with other product characteristics had been studied by number of authors. De Benedetto [De Benedetto and Klemeš 2009] created an environmental strategic map, a new tool with some new indicators for analyzing the product impacts combining environment and economy. Sakao [Sakao 2009] and Kobayasi [Kobayasi 2006] tried to combine some selected eco tools with quality tools to solve the problem at the earlier design phase. Bovea M.D. [Bovea and Perez-Belis 2012] classified and analyzed some eco tools by some indicators: The contribution area, the life cycle aspect, when it might be integrated, the nature of results, etc. But these articles did not define quantifiable methods to identify the suitable tools. Besides, as usually, the designer might treat several environmental issues at the same time, such as the recycling rate, the energy efficiency and the product's material etc. The augmentation of topics increases the complexity of dealing with them. But, till now, it's not found that the studies focused on the selection of several methods to deal with some combined environmental problems (ex: deal with recycling rate, energy efficiency and CO2 emission at same time, etc.).

The growing number of environmental methods, concepts and tools really leads to some new challenges for product designer: which inputs should be collected, what competences will be developed and how to select the suitable methods to build an "Eco product" [Hallstedt et al. 2010], [Pardo et al. 2011]. As mentioned above, the first condition, on project level, is to deliver customer's values in a timely efficient manner (combine all issues at same time) to assure that continual profitable growth occurs. [Waage 2007]. Secondly, if we consider the "Eco design" as a part of the enterprise, a same understanding of "Eco design" among different levels of the enterprise is very important to deploy all related-activities [Hallstedt et al. 2010], [Zhang and Zwolinski 2011]. The selection of eco methods for each project should be also restricted by the strategic decision from management level. These strategic decisions comply with the principal developmental-related issues, (such as the financial performance, the long-term relationship with client and suppliers, the mark or brand management etc.) and the balance between the global direction, the speed and the economics of all product segments. They pilot the global competence development in the enterprise and the establishment of all related information systems [Hallstedt et al. 2010].

All previous illustrations just consider the analysis and classification of the technique axis. In general, as a classic design, "eco design" should be seen as a set of internal functions in a company to achieve the balance of product between economic, technical and sustainable aspects [Reyes 2009], [Brezet and

Van Hemel 1997]. So it's not enough to just focus on the eco-engineering: the actions of "eco design" should be tailored according to the specifications of product which integrate the contribution from all support-services (supply chain, manufacturing, and marketing etc.) [Baumann et al. 2002].

2.2 Eco purchasing and supply management

Supply chain is a system of organizations, people, technology, activities, information and resources involved in moving a product or service from supplier to customer. The green supply chain is to indicate the supply management activities that attempts to contribute to the sustainable performance of all traditional and related-extended supply activities [Beamon 1999].
Greening purchasing and supply management relies on the deployment of relevant supply management capabilities and methods. Two main categories of green supply might be identified to classify them [Bowen et al. 2001], [Seuring and Muller 2008]:

- Supplier management for risks and performance based on "Greening the supply process"
  To answer the external pressures, the first manner is to set up an environmental management system of supply chain to avoid the environmental related risks [Greenpeace 2011]. This management system requires some minimum criteria (in accordance with the external pressures) to monitor, evaluate and report the supplier's process and its global performance [Seuring and Muller 2008]. Then, these environmental performances are seen as the prerequisites for suppliers that range and allow them to provide materials or service(s) to operate as part of the supply chain [Lamming and Hampson 1996], [Min and Galle 2001].
  In this category, the regulation and normal standards play an important role. They mainly focus on the certification of ISO 140001 and EMAS. To obtain these certifications, some activities, such as the monitoring of daily processes and the evaluation of supplier's environmental management system, are established. Then, the corporate private questionnaire which is sent to suppliers for self-audit - are usually mentioned into the papers [Baumann et al. 2002]. This self-audit indicates how the supplier deals with environmental issues and how it collects data and declares the results. Thirdly, enterprises have to take a longer part of the supply chain into account to allow an improvement in the supply relations as well as in the performance. A company-overlapping communication and a strategic training to improve the supplier's performances are usually proposed [Seuring and Muller 2008].
  Besides of above mentioned traditional activities of supply chain, according to environmental challenges, some extended activities are appearing; such as the relationship with recyclers and remanufacturers. Beamon B.M. [Beamon 1999] indicated that these activities and related material flows should be embedded into management system.
- Supply chain management for sustainable products based on the "Product based green supply"
  A manner to contribute to the needs for "Eco design" is to set up a product life cycle management to require, train and cooperate with suppliers. In order to realize a "sustainable product", the competence of suppliers plays an important role. Supplier developments are required before enterprises are even able to offer sustainable products to their customers. For example, textile and apparel producers/retailers have to make sure there is an organic cotton supplier before they are able to offer such products [Kogg 2003], [Goldbach et al. 2003]. To keep a long term relationship with suppliers, a training and cooperation on product level are considered as a key part. In this case, these communications not only require an exchange among supply chain on process level, but also on product level, when some deeper technical information should be translated [Handfield et al. 2005].
  In this category, the LCA or LCA-related methods are usually mentioned to support the enterprise to address the eco design related issues and necessary information. The additional condition is the corporate definition of "Eco design" which pre-indicates the goal and boundaries of the cooperation. The project's buyer, delegate the project team, keeps the real contact and cooperation with suppliers to achieve specific project's goal.

The figure 2 summaries the relationships as above mentioned between the enterprise and its suppliers. Commodity purchasing department delegates the enterprise to direct contact with suppliers to keep a long term strategic relationship. This figure shows that the two categories are not mutually exclusive.

There is a positive relationship between the two above categories to accelerate and complete the environmental performance [Bowen et al. 2001], [Seuring and Muller 2008]. The selection of eco design methods should involve the consideration of the acts of two categories and their internal relationships to make the coherence.

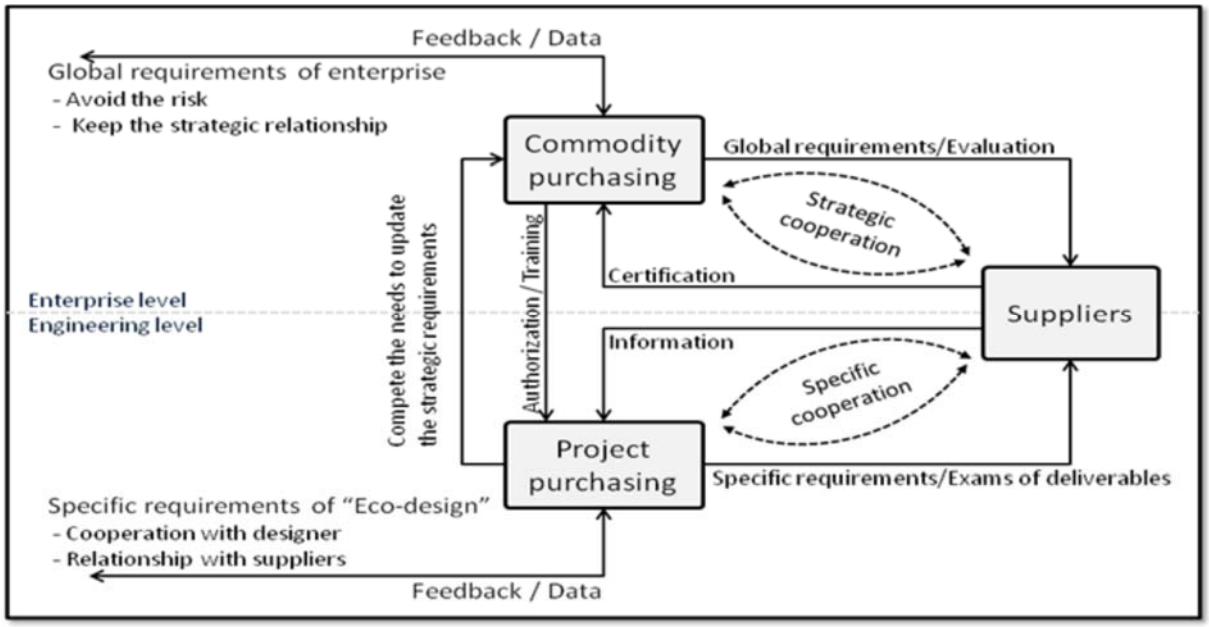

Figure 1. Relationships among the eco-activities of supply chain

2.3 Eco manufacturing

The Environmental management system (EMS) is usually used to manage and resolve the environmental problems of manufacturing facilities. ISO 14001EMS standard and related ISO 14011 play the most important role in this area. The European EMAS standard and Canadian "Responsible Care", which focuses on the activities of chemic industry, is also often mentioned. These above three standards require the manufacturing facilities to monitor, register, manage and improve all environmental related data. EMS also intends that the enterprise should set up their management organization to continuously deal with their environmental issues.

In the "plan" phase of ISO 14001, the initial review or gap analysis between the facilities and all the related manufacturing processes of a global situation is recommended. The results support the identification of all the elements of the current operations (the inputs/outputs/discharges and noise, dust, heart and VOC, etc.), which might interact with the environment [Martin 2010]. According to this review, two categories of actions could be launched, [Tibor 1996]:

- *The improvement of global environmental performance*
  To answer the local environmental protection needs and to contribute to the global performance of enterprise, some topics are usually selected to be solved [Reyes 2009]:
  1. Local surroundings: Compliant with regulation / the complaints from neighbors
  2. Waste: collection center / risks control / reduction program / encourage recycling
  3. Water pollution: separate the rain water and waste water / interceptors, filtering recycling
  4. Perturbation: Measure discharge to atmosphere / Land use
  5. Other risks and hazards: various power usage / solvent storage
- *The improvement of certain manufacturing processes*
  According to the global improvement planning and some specific requirements of production from eco design, there are certain actions which focus on the improvement of the product manufacturing process. Based on the LCA of products, the best available technologies are identified as new solutions to optimize the environmental impacts. [Nieminen et al. 2007] Above topics or evaluation indicators of the first category could be used also for this

improvement. But some operational topics and indicators of production process are decided by the designer [EuP directive 2005], such as the selection of input materials, the definition of production manners, etc. So a relationship between the manufacturing faculties and eco design is necessary to accelerate this improvement. Inversely, the improvement of manufacturing process contributes also to the eco design results which are developed by design team.

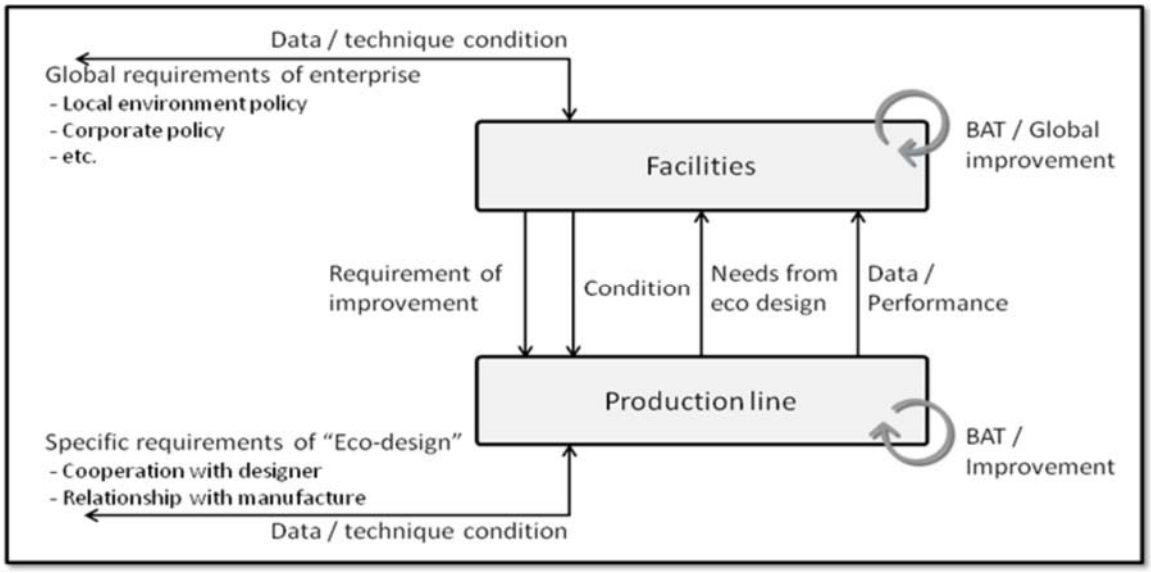

Figure 2. The summary of relationships among the eco-activities of production facilities

Figure 3 summaries all above mentioned relationships between the improvement of facilities performance and the improvement of some production line, which has a direct relationship with eco design practices. On one side, the needs of facilities provide the general constraints and the requirements of environmental improvement in manufacturing area to each production line. With the deployment of BATs - Best Available Technologies at facilities level, it also modifies the environmental conditions for each eco design practices. On the other side, the eco design practices make same optimization of its production line, which directly changes the performance of facilities. So an analysis of all relationships has to be developed to have a suitable selection of eco design activities.

2.4 Eco communication

The eco communication is defined as all the communication activities, through dissemination of publications (booklets, marks, reports in all kinds of form: paper or electronic) or through the completion of events (seminars, conferences and exhibitions, etc.). It contributes significantly to various environmental improvements [ADEME 2005]. Those improvements might indicate the activities of enterprise, or their performances throughout the product life cycle [WRI 2010].

The eco certification of enterprise's environmental performance is more and more visible. The certification report of ISO 14001 could be considered as an important example. Besides, there are other evaluation systems, which were established by some independent third party, to monitor, evaluate and support the improvement of the enterprise's activities. We launched an analysis showing that from 84 found eco labeling system in textile industry, there are 31 evaluation systems focused on the environmental performance on enterprise level. To obtain the certification, the enterprise might set up a set of criteria to comply with the requirements on certain activities, including engineering, purchasing, industry, etc. Those criteria might have an influence on the decision for the selection of the eco methods for designers.

Till now, the environmental product declaration systems had become a wide-spread method in order to fulfill the effective market communication around the eco consumption. The voluntary Eco labeling systems presented an important role. ISO divides the environmental labeling into three categories:

- Type I eco labeling was established by a third independent organization which identifies overall environmental performance of a product or service within a specific category based on

life cycle considerations [WRI 2010]. The criteria of each label were set up according to the common significant environmental topics of such product/service throughout entire life cycle of product. But even for same product's category, the criteria from different labeling systems are not similar. This distinction leading to these standards cannot be used directly by the enterprise to establish uniform standards for an international market. But on project level, in order to answer the extern requirements, some criteria of certain eco labeling system might be involved into the specification of the product as a reference of development. A method which supports the project to analyze and check the compliance of the product with the criteria of eco labeling, had been developed [Houe 2009].

- Type II and type III eco labelling allow the enterprise to self-declare their private environmental claims. Similar with type I labelling system, type II system create an endorsement marks system to have an effect on the purchasing decisions of the customers. The type III system, which provides quantified environmental data of product, is intended for B-to-B business mode. These two private systems are feasible to set a normal standard for all products on international marketing. So the corporate definition of "eco design" and "eco product" should been considered and embedded into the establishment process of those systems.

As above mentioned in the section about "eco engineering", enterprise develops its eco competences and related support system according to its corporate definition of "eco design" and "eco product". The eco communication, as a part of support system, has to be identified following this definition. The product communication plan should consider this definition and integrate it with all real market needs (for example, type I eco labelling). We believe that an interactive relationship between those two levels could accelerate the improvement of the entire environmental performance for both the product and the enterprise.

3. Need for a unified environmental view to integrate the eco design activities

The above chapters tried to make a review of typical eco activities for principal functions of the enterprise - engineering, manufacturing, supply chain and communication. In each section, the profits and all related environmental objectives could be classified into two generic axes:

Axe 1: The eco activities which contribute to the global performance of the enterprise

Axe 2: The eco activities which contributes to the needs for eco design throughout the entire life cycle of the product

The activities contributing to the needs of the two above axes are not exactly independent. On the contrary, they are mutually constrained, and sometimes, they are mutually supported. As above mentioned in the precedent chapters, the selection of eco method to answer one axe's needs, should consider the constraints from another one. For example, an enterprise's private definition of "Eco design" is defined focusing on the topics of material, such as the dematerialization, the decrease of hazardous substances. This strategic definition provides a corporate objective of competence development, the topics of internal training and the recruitment needs. But the lack of competences leads to a low level support to other needs coming from some projects, such as the energy efficiency or GHG emission. So the selection of methods to answer these topics for the project should be enough simple and easy to understand by no professional person. On the contrary, the establishment of corporate "eco design" definition and some global environmental improvement could also optimize the condition of the implementation of some eco design activities in the project. So we hypothesize that a systematic conversation channel between two axes could support the enterprise to make a suitable identification of eco design activities and related eco methods [Greenpeace 2011], [Hallstedt et al. 2010].

Transverse, as a united organization, the selection of eco design activities and related eco methods in enterprise need to consider also the coherence among different corporate functions, such as the competences and abilities of each function, the working flow and collaborative channel, and the actual database, etc. ISO 14000 series and other classic LCA methods presented that a classic and precise product life cycle improvement measured and realized into design team should be supported by some contributions of operational departments, such as the production process, the imported materials

evaluation and the logistic optimization, etc. But these contributions could not only follow the requirements of LCA. They should be coherent with their departmental context (competence, habitude, location and finance situation etc.) and related development tendencies. To answer several environmental issues at the same time, the designer might launch some different eco activities using different eco methods. [Zhang 2011] presented the same points through an industrial review of the corporate eco design programs of electric and electronic enterprises. [Zhang 2011] The growing number of used methods might lead to an additional challenge of method selection: How to optimize the network of eco design methods. In other word, does an implementable method affect the dynamic operational context to select another parallel one? At first, this optimization might take the sharability of data flow into account. The sharability means the maximum sharing of necessary inputs to each eco activity (by the common data) or making the data-bridge to transfer the data form to answer several needs. For example, if the supplier could provide a certification on a global level to attest there is no RoHS substance used into their process, the project could directly transfer this information on material's level to avoid double requirements for the same thing. This kind of input's number reduction might encourage the positivity of each stakeholder and reduce the negative influences on the actual system. Secondly, this optimization might also take the co-operability among different eco activities into account. The typical analysis might be to establish a chain of activities which plans all as an entire program (ex: the outputs of some eco activities could be used as the inputs of others). This chain of activities might reduce the complexity of the cooperation, the related cost and time use, and also it's positive to explain to all employees the signification of each activity which encourages the final achievement. So, a hypothesis is that there is a positive influence to take all relationships among eco activities and related methods into account according to the context of an enterprise. This relational analysis could support the identification of the suitable combination of eco methods. And this harmonization of selected methods might accelerate the corporate environmental optimization.

Although there are several available eco methods and tools to assist the realization of eco activities, [Baumann 2002] underlining that there was a lack of systematic perspective and relationship between strategic intents and eco design practices. [Hallstedt et al. 2010] Indicated the similar point, a systematic view of enterprise and a common language which ensures the comprehension between different functions or between different levels in enterprise are necessary to be developed to support the realization of eco design. In 1996, a uniform framework of Strategic Sustainable Development (SSD framework) has been developed [Robert et al. 2002], [Hallstedt et al. 2010] to find out a general applicable definition. This framework has successfully identified the general frontier and the interface for different levels in the enterprise to deploy the environmental program. But it did not provide the practicable criteria or indicators to support the enterprise make the decision. [Reyes 2007] proposed a "trajectory" methodology to guide the medium-small size enterprise to plan some eco design related activities. She did not take the axe of global performance into account. Zhang F. [Zhang 2011] indicated that the adaptive eco design action or actions group should be prioritized and identified from the complex constraints of enterprise, such as the strategic position, the technical capacity and implementation situation etc. And he proposed an internal decision-communication system to describe all environmental issues/problems by a common language. But he did not touch the details on method level.

Finally, according to these above needs and the lack of related researches on systematic relationships among the eco activities in enterprise, a framework to identify the suitable eco design methods and the tools need be developed. Beside of the classic criterion, the requirements of customs, this framework could take a systematic analysis which needs to consider:

- the coordination with the corporate global direction, which might includes the corporate definition of "Eco design" and the related competence and source development situation, etc.;
- the cooperation with other corporate functions considering their complex context;
- the cooperation with other executing eco design methods and related process to treat about several issues at the same time;

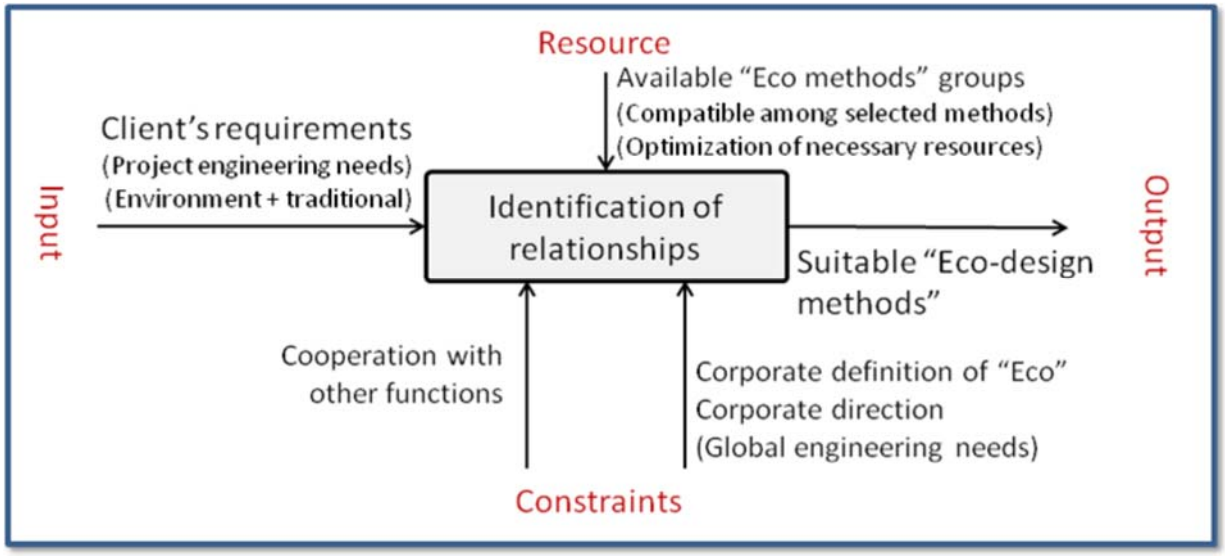

Figure 3. Identification of the suitable eco design methods

4. Conclusion

Based on a literature review of the different eco activities in different corporate functions, this paper tried to classify these activities into two contribution axes: those that contribute to the corporate global performance development and those that contribute at the product level. The literature review showed also that these two axes are not yet coordinated and indicated that this coordination has to be developed to harmonize the eco activities in the enterprise to increase the whole eco -efficiency. To accelerate the integration of the suitable eco design activities, a systematic analysis model has to be proposed. It will treat with the relationships among different eco activities and related methods on global level, to support the selection of suitable eco design methods.

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