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The Environmental Performance Strategy Map: LCA based Strategic Decision Making

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Life Cycle Assessment (LCA) is a well used tool for analyzing environmental impacts on a wide perspective and with a reference to a product system and economic activity. However it has some limitations and there is a need for a novel approach that complements environmental and financial considerations is addressed in this study with the introduction of a new graphical representation: the Environmental Performance Strategy Map. This particular graphical map allows combination of the main environmental indicators (footprints) with the additional dimension of cost. The paper defines the Sustainable Environmental Performance Indicator as a single measure for sustainability of a given option. Comparison of different options for strategic decision making purposes can be enhanced and facilitated by the use of this indicator.

1. From Environmental Assessment to Strategic Environmental Map

The ecological footprint is a way to compare human demand with our planet capacity to regenerate it and it is measure of our burden on the ecosystem. Usually it represents the amount of biologically productive land and sea area needed to regenerate the resources consumed and to absorb the corresponding waste. Different footprints have been developed to consider the impact of different resources. In a broader view the ecological footprint is related to the method of LCA, which is typically used for products and services, but also applicable for production plants and regions. One of LCA advantages is that it better covers the whole range of impacts, and it may also provide an accounting of the upstream impacts.

Nevertheless, one of the most important limitations in the application of LCA as an input for strategic decision-making from an environmental perspective is the limited inclusion of cost and investment considerations. A new approach is required to integrate financial, environmental, resource and toxicological considerations into a single analysis. The core of the concept is to calculate some specific sustainability indicators based on LCA. This will help one define the relevant contributions to support strategic

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decision making. The cradle to grave approach will assure that all environmental and human consequences taken into account. These consequences have to be further balanced against financial and resource consumption considerations.

To represent these relations and to compare options from an environmental and, more generally, business perspective a new graphical representation needs to be introduced: the Environmental Performance Strategy Map (EPSM). The objective of this representation is to build upon the strength of Ecological Footprint and Life Cycle Analyses to provide a single indicator for each option. A potential user can analyze this indicator to direct the decision-making process towards the best option from a sustainability and environmental perspective.

The first step in building the EPSM correctly is to calculate the impact of the option under analysis for all of the main environmental burdens. The combination of these elements and the cost perspective will provide a single indicator to assign to each option. The comparison between different options, with different characteristics and ratio of advantages and disadvantages are facilitated also by a graphical representation. The best option from an environmental and financial perspective will be selected based on this approach.

2. Selection of Footprints

Different methods have been developed in the last years to correlate environmental sustainability of specific activities with land and water areas required to supply this activity with resources and to absorb its wastes (Monfreda et al. 2004). This is usually referred to as Ecological Footprint.

Some initial objections to the original method on the way energy is accounted for (Fernng 2005). The difficulty in using the tool in the decision making process have been noted by Ayres (2000) and overcome by the development of specific indicators - SPI (Krotscheck and Narodoslawsky 1996) and DAI (Eder and Narodoslawsky 1999). In particular the Sustainable Process Index (SPI) considers the area as a basic measure: the more area a process requires, the more its burden from an ecological point of view. The SPI method is based on the comparison of natural flows with the mass and energy flows generated by a technological process. The calculation of an SPI centres on the computation of the total area required (A_{tot}):

$$A_{tot} = AR + AE + AI + AS + AP \qquad (1)$$

where AR is the area required to produce the raw materials (given as the sum of the areas to provide renewable raw materials, fossil raw materials and non-renewable raw materials), AE is the area needed to produce process energy, AI is the area required for the process installations (equipment/plant), AS is the area required for support staff and AP is the area required for the accommodation of products and by-products (Krotscheck and Narodoslawsky 1996).

A model that proposes the combination of ecological footprinting with economic considerations is proposed in the Ecological Value Added system (Kratena 2004). This is based on an input-output system and upon the ecosystem pricing concept, introduced via energy values and the ecological footprint. The balance between carbon sinks and emissions defines the sustainability target for this model.

To provide a more comprehensive analysis of the interaction of the environmental burdens and financial costs newly developed Environmental Performance Strategy Map is based on the combination of various footprints (further details are available in De Benedetto and Klemeš 2009):

- Carbon footprint (Hujbregts et al. 2008, Wiedmann and Lenzen 2007)
- Water footprint (Hoekstra and Hung 2002, Hoekstra 2008)
- Energy footprint (Land, Renewables, Non-Renewables) (Stoeglehner 2003)
- Emission footprint (emissions in Air, in Water, in Soil, Waste materials) (Sandholzer and Narodoslawsky 2007)
- Work environment footprint (work-environment and toxicological impacts) (Schmidt et al., 2004)

3. Building the Map

Once the contribution of each option to the specific footprints has been calculated, it is possible to build the EPSM. The basic concept is to map the footprint on a specific spider-web plot, in order to identify a meaningful combination (Fig. 2). To compare measures the results of each footprint are normalized, resulting in a scale from 0 to 100. A deviation-from-target methodology is proposed, where for each of the footprints, the authors of this paper define a maximum target and express each value recorded as a percentage. The aim is to lower as much as possible, in percentage points, the contributions of each footprint to the overall combined Indicator. The targets are either based on maximum available resources or are drawn from scientific consensus or regulatory requirements.

Each option has an area assigned that represents a combination of all footprints. To specify the cost and financial impacts an additional dimension has been introduced (Fig.1).

This is the cost of the option under analysis. Cost is considered as an additional dimension because it is not used for comparative reasons. The indicator takes into account the total financial investment required for each options. The volume of each pyramid represents the overall environmental and financial impact of the option under consideration. The authors of this paper define this index as the Sustainable Environmental Performance Indicator (SEPI).

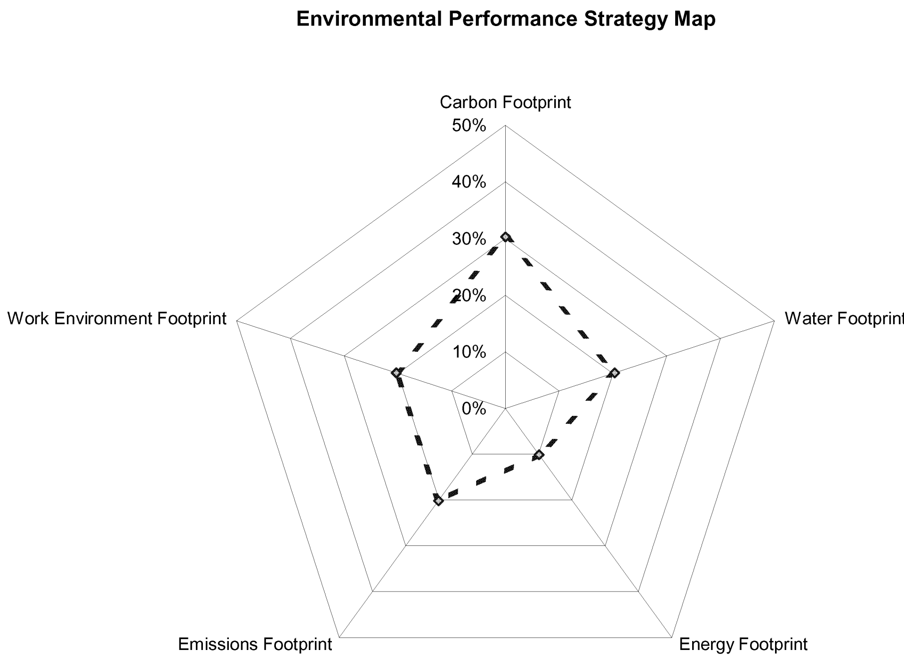

Fig. 1 Plotting the footprints in the EPSM

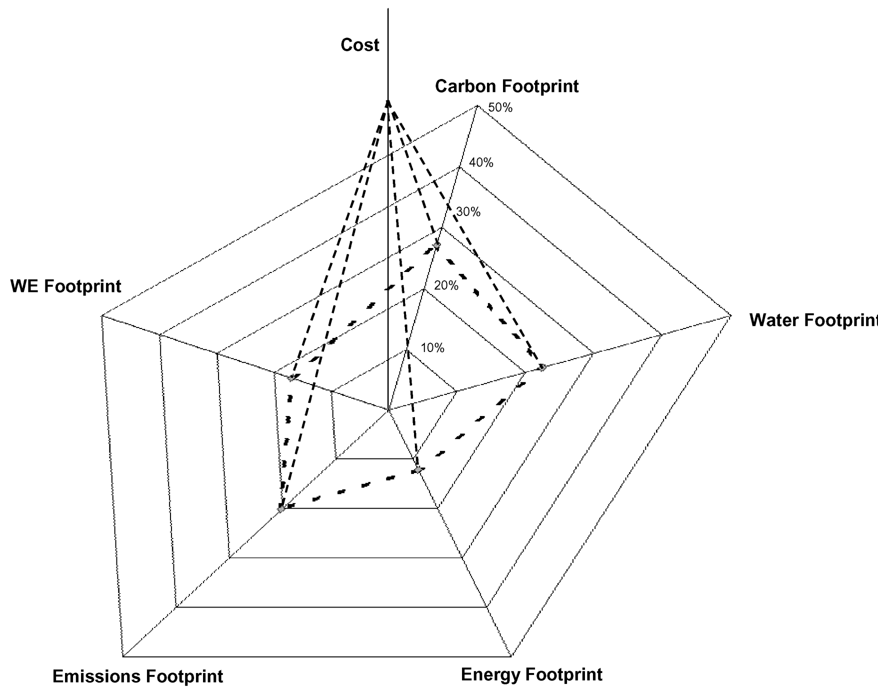

Fig. 2 The additional dimension in the Environmental Performance Strategy Map

Finally it is possible to plot all options under consideration in a specific EPSM. The map thus enables comparison of different options for strategic decision-making purposes, based on a single Sustainable Environmental Performance Indicator.

4. The Sustainable Environmental Performance Indicator and Policy making

Considering the interrelations and the complexity of Environmental issues, decision-making in this field is very difficult. This is particularly true if it is not supported by analytical tools and reliable metrics. The Sustainable Environmental Performance Indicator, as proposed in this study, does not aim at being the single metric that policy makers should rely on. Encompassing environmental and financial issues, it is instead a useful tool that can help them in the decision-making process and could be adopted to compare different options and their comparative impacts on societies and on the ecosystems upon which they are totally dependent. In particular with its "deviation-from-target approach", SEPI provides a way to measure the effectiveness of environmental policies against performance targets. SEPI can be a valuable tool to investigate different options to a given environmental problem. For instance, if we mandate the reduction of the water consumption by 20%, this is reflected in a drop of SEPI by 7% points. In this fashion we can simulate the different options and propose the one with the highest possibility of reduction of the environmental burden

5. Conclusions

Starting from the limitations in the use of LCA as a tool for strategic decision making, this paper introduced the Environmental Performance Strategy Map as a possible solution. This particular graphical representation is designed to provide a single indicator – the Sustainable Environmental Performance Indicator – to extend the use of footprints as mere communication and awareness tools. The introduction of the financial aspect complements the environmental and work environment considerations and provides a more holistic answer to the sustainability of specific options. In particular SEPI can be successfully applied to provide an overall indicator of the environmental performance of existing applications or can be used as supporting tool in comparing competing options in a strategic decision-making process. This offers potential balancing and minimizing environmental impacts as energy/carbon footprint, water, emissions, working environment and quantifying them into one indicator

6. Suggestions for future research

The SEPI is an important step in the debate on defining the appropriate metrics and methodologies for evaluating environmental performance. Specific case studies in the field will provide the occasion to further refine and validate the SEPI as a relevant tool in strategic decision making. Expressing as area processes that are area-based (e.g. agricultural processes) is relatively easy. Converting to an area processes that are not primarily area based such as a chemical process can prove problematic. Further developments of this tool should address these problems.

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