EPS as a Life Cycle oriented System Assessment Tool to Facilitate Industrial Learning about Relations to the Environment

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Abstract

Many Swedish companies are interested in readily understandable guidance on environmental aspects. The computerised assessment tool EPS is designed to meet such information needs in product design and business decision making. The EPS index methodology enables more explicit specification of environmental relations, values and trends for evaluated systems. This paper illustrates how EPS has been used to clarify a life cycle perspective and its validity in a comparison of a Volvo Environmental Concept Truck and a conventional truck. The explicit visualization of environmental characteristics has served as a common focus in interdisciplinary communication and thereby as a foundation in continuous learning.

Introduction

Environmental protection is becoming an increasingly important issue for world industry. In order to enable sustainable product development and to guide industry to adopt eco-efficiency and a life-cycle thinking into commerce, there is a need for readily understandable system assessment tools. One method that has been specially designed to meet the needs by product developers is the EPS-system (Environmental Priority Strategies in product design). In its first version the EPS system was developed during 1990 and it has then been further improved in the Product Ecology Project, a joint three year activity by the Swedish Federation of Industries, 15 major companies, the Chalmers University of Technology and the Swedish Environmental Research Institute. EPS is based on the Life Cycle Assessment methodology. The product environmental LCA has been subject for an intensive development and debate during the last five years. ISO has recently forwarded an international standard on the LCA procedure (ISO). The EPS systems perspective follows this standard. The EPS system has been used in a number of industrial evaluations of, for example cables, refrigerators, printed electric circuits, gasoline, packaging materials and car parts.

EPS system design

A company is dependent on customer preferences for its products and services. This means that, a company has to consider its customer societies general environmental view. In the same way as with other marketing aspects, a company can influence societal preferences in environmental matters, but it can not go against what its customer wants or invest to much ahead of the market development. Consequently, this version of EPS environmental load unit, ELU, is designed as a measure for societal environmental priorities, by means of willingness to pay (WTP) assessments. The basic method evaluates emissions by means of WTP for changes caused by the emissions on the environment. Raw material resources are evaluated by WTP for alternative renewable methods to produce comparable utility. For further details see (Steen).

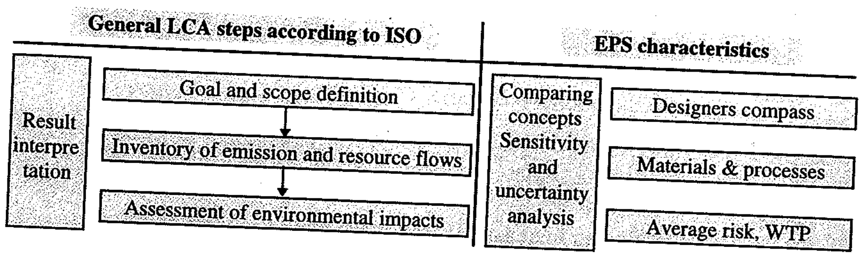

Figure 1 Some principles of EPS in relation to ISO 14040 standard

The EPS system has been developed in a top-down approach. The early specifications was based on what the designers would like to know in order to be able to decide which environmental concerns to follow in a choice between two concepts. From this basis the methodology, computer programs and databases was gradually developed to use as much as possible of existing knowledge from environmental sciences. The input to the models was data on use of resources and emissions from processes involved in the life cycle of a product, as well as risk assessment and valuation models for resulting environmental effects. The output of the model is a measure corresponding to what a fictive global society consisting of OECD-economies would be willing to pay today to avoid the changes in the environment caused by the product life cycle if it had to suffer from it itself. The measure is expressed in ELU (Corresponding to one ECU). Below an example will be given of how the EPS system has been used as an environmental management tool at the Volvo Truck Corporation.

Comparison of an environmental concept truck and a traditional truck

Environmental LCAs always deal with environmental impact in relation to service value. The main concern in the design of the ECT was to obtain a high service capability, e.g. by a qualified Driver Control & Information System and by enabling a turning circle as low as 17 m. Volvo has a long tradition in safety, not only for the driver. In this ECT project it has also been noted that there are other risks for surrounding systems and humans than the conventionally noted environmental impacts. The ECT is designed as a city vehicle and for example the cab design takes a strong interest in the eye contact between the driver and other city space users. In this paper we focus on environmental loads such as emissions and natural resource depletion.
There is a discussion about policies to promote investments in alternative fuel vehicles. For example, a feebate system is suggested to encourage a fast introduction of electrical vehicles and it seems possible to manage such a temporal shift of capital between different years (Ford). The example below deals with some of these aspects and is a comparison between a Volvo Environment Concept Truck and a conventional FL6, focusing on engine and transmission.

Figure 2 Environmental concept truck (ECT)

Figure 3 FL6 truck

The ECT is a hybrid vehicle with a gas turbine for charging a nickel-metal hydride battery pack. The FL6 is a conventional truck. General data are shown in table 1.

	ECT	FL6
Loading capacity	15 ton	18 ton
Power	142/94 kW	132 - 184 kW
Torque	2850 Nm	550 - 825 Nm
Power source	Ethanol/electricity	Diesel
Main material	Aluminum	Cast iron/Steel
Driveline	Gas turbine/NiMH-batteries	Conventional diesel
Nitrogen oxides	0.5 g/kWh	6.3 g/kWh
Zero emission range	25 km	0

Table 1 General technical truck data

The life cycle impact value of emissions and resource use of the ECT and FL6 trucks has been evaluated by means of the EPS system. The main result are shown in fig. 4.

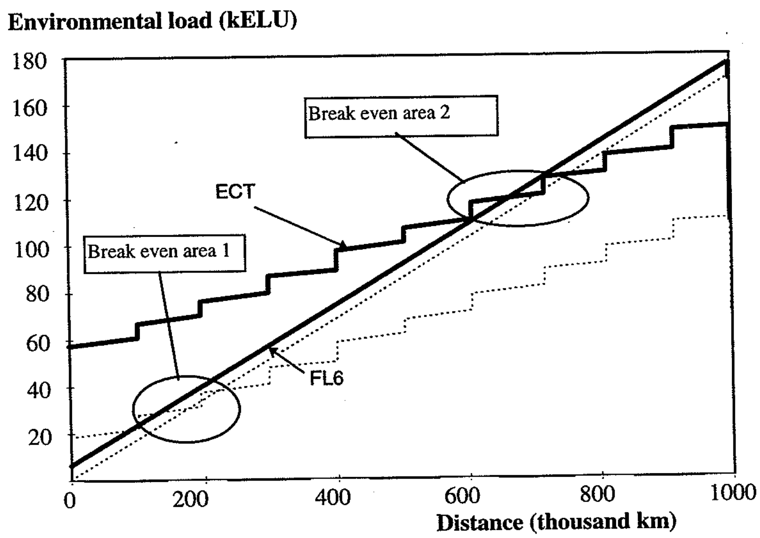

Figure 4. Accumulated environmental load as a function of driving distance, if assuming battery replacement every 100 000 km and recycling of batteries.

The truck life cycle assessment deals with the environmental load per transported quantity and distance (e.g. load/tonkm). In this case, both truck alternatives have approximately the same loading capacity and consequently we can focus on an assessment in relation to distance covered. The possible total operational distance is quite similar for the two alternatives, but for both alternatives the useful life is dependent on e.g. maintenance and financial considerations. Consequently, it is instructive to study a graph of environmental load as a function of distance. The direct and indirect load that is caused by primary production and is larger for the ECT than for the FL6, because of higher resource values for rare metals used in batteries and electronics. Direct and indirect effects from the truck usage phase are mainly due to emissions and fuel consumption. The ECT also has a considerable environmental load for battery exchanges, which has been assumed to occur every 100,000 km. Finally there is a waste management load and a residual material. Many of today's residuals are negative for human sustainability, but for some interesting materials the residual is a recycling resource that enables a saving in future environmental load, i.e. a positive effect for human sustainability in the environment. To a large extent the trucks consists of metals for which there is a considerable load saving by recycling. Consequently, the recovery of the truck material has a positive effect on the human resource situation.

The figure 4 accumulated impact lines show a break even at approximately 700,000 km (break even area 2). At a closer look this is a biased view, because the positive recycling value is larger for the ECT. Provided that the recycling is done and that there is a true demand for the materials at that point of time it is more relevant to make the comparison for the dotted lines, where the end of life load saving has been subtracted. In this view it becomes clear that the break even happens at about 200,000 km. The transformation of view, from bold to dotted lines, means quite a difference in the perception of the environmental characteristics relation between the two vehicles. The difference between the two comparisons is that the bold lines perspective disregards the difference in future environmental load, whereas the dotted line perspective takes the total life cycle into consideration, as a basis for how the environmental comparison of the trucks varies with the usage distance. This last perspective seems to show a more readily understandable picture of the relation between the actual total life cycle loads (Karlsson 1995).

Validity assessment

One of the most important aspects of an environmental assessment is to clarify its validity, uncertainty and sensitivity. At a basic level this applies for all forms of decision support, and it is very important in multidimensional analyses, for example in environmentally related comparisons of product life cycles. It is hardly possible to calculate readily understandable environmental values, such as the ELU indices, that are very precise and unobjectionable. What one can do is to assess and keep track of the uncertainty. The EPS system contains such tools.

The uncertainty in the priority given by the analysis is calculated by using estimations of uncertainties in all input data and using a Monte Carlo method. The results are shown in figure 5. The diagram shows an 80% probability that the ECT is environmentally preferable. It also shows that there is a 20% probability that the FL6 is better than the ECT. This result may appear to be very unclear, and it may seem to be quite frustrating as decision support. However, we think that, this illustrates a rather common phenomena in decision making about complex systems. The uncertainty is there and Figure 5 is only a visualisation of what decision makers often have to live with.

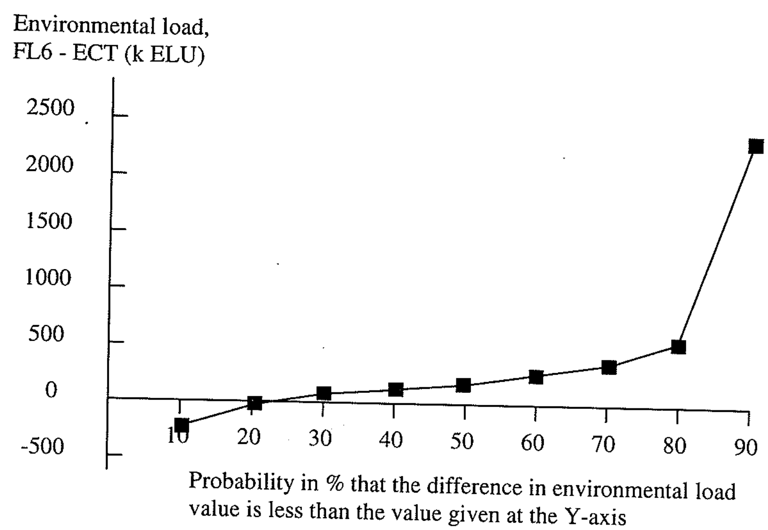

Figure 5 Probability distribution for the difference in load between FL6 and ECT

Continuous learning

One EPS system primary objective is to tell designers which one of two different concepts that is least impacting on the environment and to find ways of decreasing a products environmental impact through its life cycle. By inclusion of a recycling model the system facilitates sustainable product development that to an increasing degree focuses more on materials, and not only on specific products. The material indices facilitates a systems thinking based dialogue about where high leverage actions may be found. From a quick primary calculation of the overall impact value for a product using general impact indices for material production, maintenance, material recycling, depositing, composting, incineration etc. the product environmental impact assessment can be gradually refined as the information grows during the product development process.

The above comparison shows a clear environmental advantage for the ECT compared to the FL6. Other EPS based evaluation can be used to show how the environmental characteristics for the FL6 can be improved considerably, for example by a change to ethanol or aluminum. But, still the ECT has a zero emission advantage by use of batteries. Furthermore, the basic reason for Volvo's work with this environmental concept car is not that exactly this design is thought to be the absolute optimum. The reason for this project is to stimulate the continuous learning and thinking about new possibilities.

The EPS methodology enables conceptualization of environmental relations and their specification as explicit values, trends and validity clarifications. It is designed primarily as a decision support tool for product design etc. In Volvo's experience, its main long-term advantage is that the explicit specification of environmental characteristics serves as a priority guidance for additional environmental analyses and as a foundation for dialogue and thereby further clarification. This form of interrelation between cumulative learning and continuous effectiveness improvements is discussed in (Karlsson 1997).

Conclusion

One main project conclusion is that the EPS system facilitates continuous learning through more explicit dialogue about the relation between the own product system and its surrounding systems, based on an environmental frame of reference.

Environmental assessments does not produce absolute truths. What we can do is to specify more explicit environmental relations, values and trends for the evaluated systems. In this way we get a platform for further assessment and discussion of various aspects. The above ECT assessment exemplifies how EPS is used as a basis to describe a readily comprehensible view of product life cycle loads and to clarify the validity of an environmental product comparison. Such illustrations have been found useful as systemic clarifications in Volvos continuous development of new vehicle concepts and this observation about industrial learning is in agreement with our general experience from the Product Ecology Project.

Acknowledgments

The support from the Swedish National Board for Industrial and Technical Development and the Swedish Waste Research Council is gratefully acknowledged. The case is based on work by David de Val and Jens Wiksell at Volvo.

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