Development of an Environmental Evaluation Tool in the Transport Sector and Its Impact on Decision-Making in the Early Stages of Design

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Abstract Due to government policies and regulations as well as customer and societal demands, organizations around the world are looking for ways to manage their economic, environmental and social sustainability. One of the most frequently used standards for organizations seeking to manage their environmental responsibilities is ISO 14001. This framework, however, is generic because it can be used by any organization irrespective of sector, activity or core values. Therefore, implementation of generic guidelines might result in the use of alternative tools that respond better to specific organizational needs and that provide outcomes that can be useful for decision-making. Through case study methodology, this paper shows how Volvo Group, a world-leading producer of transport solutions, developed an internal environmental evaluation tool called Environmental Screening (EnvS) to improve the environmental performance of its solutions.

1 Introduction

The degradation of the environment through resource extraction, manufacturing, use and disposal of products, as well as the provision of services has been one of the main drivers for societies and governments to look for more sustainable alternatives. The United Nations Conference on the Human Environment in 1972 in Stockholm was a milestone for raising awareness of the actions needed to tackle environmental deterioration. Currently, sustainable initiatives can range from global efforts, such as the UN Sustainable Development Goals [1], to regional directives

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like the WEEE directive for electronic waste [2] and EVL for the end-of-life of vehicles in Europe [3] to local environmental objectives (e.g. Sweden's 16 environmental quality objectives) [4]. Furthermore, participatory initiatives and standards for companies and organizations such as the Global Reporting Initiative (GRI) and ISO standards demonstrate efforts undertaken towards sustainability. With regard to the environment, ISO 14001 exemplifies the participatory action that companies may take to reduce their impact on the environment. However, this standard is general and differences still remain, for example, organizations differ in how they are organized, what they offer, their business model and their core values. These differences may lead to the adoption and adaptation of tools that support decision-making in contexts suitable to the organizations and their specific circumstances [5, 6]. A problem area that is frequent in product development organizations is that environmental awareness initiatives are based at the manufacturing level and not at the product level [7], resulting in narrow coverage by an environmental program. Through case study methodology, this paper offers a unique view on how Volvo Group developed Environmental Screening (EnvS), a tool aimed at improving the environmental performance of its products and solutions. In this regard, three research questions are postulated.

- How can an environmental evaluation tool towards sustainability be used more in practice at a large company?
- How can internal organizational needs be identified and addressed in order to develop an environmental evaluation tool towards sustainability?
- How could an environmental evaluation tool support decision-making in the early stages of design towards sustainability?

2 Background Research

The scientific literature provides several examples of how organizations can adopt and adapt tools to reduce the environmental impact of their operations. This is especially important in the early stages of design, given the greater potential there to reduce the environmental impact of products and services [8]. The early stages of design seem to benefit most from qualitative and easy-to-use tools. This could be partially explained by the lack of information, risk, uncertainty and subjectivity found during the early stages [7]. Schöggl et al. [9] suggest that qualitative tools are preferred at this stage, due to the lack of information and difficulty in quantifying environmental impacts. Tools and methods that address environmental impacts usually fall under the umbrella of Design for the Environment or Ecodesign [7], which can be described as an approach that addresses the environmental impact of the entire life of a product or service, from the early stages of design [6]. Tools following this approach are plentiful. Pigosso et al. [10] identified 350 publications between 1993 and 2015 dealing with tools and methods related to Ecodesign. However, Rousseaux et al. [11] suggest that there is still low uptake of such tools.

Reasons for this can be due to lack of knowledge about the tools, lack of specialized staff that can use such tools, company size and low cooperation between departments. Poulikodou et al. [12] further identify obstacles to the use of environmental tools; for instance, tools may be too vague, many checklists are already available, tools need detailed information, the competence of users is low and there are delays from suppliers. Bovea and Elis [13] identified checklists, matrices and rules or guidelines (e.g. 10 golden rules of ecodesign) among the most often used qualitative and semi-quantitative tools. Knight and Jenkins [14] also suggest that some of the most common or preferred ecodesign tools are in the form of guidelines and checklists. An example of this can be seen in the work by Lindahl and Tingström [15], who adapted Failure Mode and Effect Analysis (FMEA) to develop a checklist for environmental considerations called Environmental Effect Analysis (EEA). EEA requires qualitative information as opposed to Life Cycle Assessment (LCA), which requires quantitative data and which users may find lengthy and difficult to use [13].

More recent tools not only addressing environmental aspects but also social and economic ones have also been proposed in the literature. For instance, Hallstedt [16] proposes a sustainability criteria matrix targeting the early stages of product development and a qualitative measure called sustainability index for decision support. Schöggl et al. [9, 17] propose the Checklist for Sustainable Product Development (CSPD) based on questions divided into four sustainability principles and 9 categories where a sustainability expert is crucial for the use of the tool.

Furthermore, Fitzgerald et al. [9] suggest that guidelines and checklists need to be company-specific and integrated systematically in the product development process, and that using standalone and generic tools may not be effective. Hence, specific procedures should be determined to avoid confusion on when and how to use such tools. Fitzgerald et al. [9] divide decision-making in new product development into two broad types: design decisions and management decisions. Design decisions address questions like what should be designed and determine shape, size, materials, processes and components. Management decisions address questions that attempt to ensure the design will result in a successful product. What will be done—and when and who will do it—are some management questions. It is therefore important to be clear about the purpose of the tool as well as who is going to use it, the necessary inputs and the beneficial outputs. The following case study further supports the use of an environmental checklist.

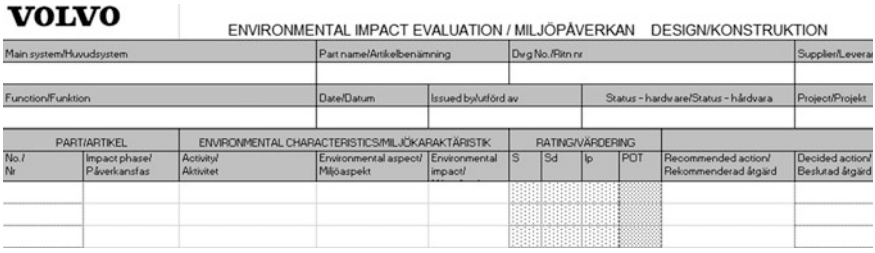
3 Case Study

Since 1989, Volvo Group has pledged to minimize the environmental impact of its operations through adopting a life cycle approach in its operations [18]. Today, Volvo's White, Grey and Black Lists for materials selection to substitute, caution or avoid materials, respectively [19–21], are an example of its commitment to reduce environmental impacts. With regard to environmental standards, Volvo Group

began using the Environmental Failure Mode Analysis (E-FMEA) in 1997 in order to fulfil requirements in ISO 14001 for product development. However, since FMEA was a protected name the group changed it to the one described by Lindahl and Tingström, Environmental Effect Analysis (EEA) [22]. After some time, Volvo Group renamed the tool as Environmental Impact Analysis (EIA), which was later standardized within the group. Due to internal and external needs EIA was further developed, customized and replaced in some projects by the Environmental Screening (EnvS) tool.

The EIA as well as EnvS are based on forms to be filled in at cross-functional meetings for Product Development (PD) projects where representatives from PD, production including logistics, aftermarket and purchasing (when relevant) participate. A facilitator who has prepared and also has knowledge of the method and environmental aspects leads the meeting and fills in the forms. At the meeting, actions are determined and followed up on afterwards. The EIA has most frequently been used to evaluate new design of powertrain components since these components may impact the environment, especially during the use phase. The tool has also to a great extent been used to evaluate the design of packaging materials, since these are often volume products and easy to assess. It has, however, not been used for all PD projects. A reason for this is that users considered the tool to be too time consuming, and with little benefit since there already are checklists for this (e.g., chemical use and standards for marking of parts, facilitation of recycling) and environmental demands are already in place for technical requirements in PD projects. Another reason for the lack of use of the EIA tool has been that it is also highly dependent on the knowledge and experience of the meeting participants, increasing the possibility to miss environmental risks and making it more dependent on the previous knowledge and experience of the users. Figure 1 partially shows the EIA tool.

In comparison, the format with a checklist in the EnvS ensures that the environmental risk factors considered most important are covered. Furthermore, several external factors have influenced the need for EnvS as a new tool that could incorporate new demands. For instance, in 2015 a revised ISO 14001 places more emphasis on products, services and a life cycle perspective. The standard states in its Sect. 6.1.2: *Within the defined scope of the environmental management system,*


VOLVO

ENVIRONMENTAL IMPACT EVALUATION / MILJÖPÅVERKAN DESIGN/KONSTRUKTION

Main system/Huvudsystem		Part name/Artikelbenämning		Dwg No./Ritn nr				Supplier/Leverar
Function/Funktion		Date/Datum	Issued by/utförd av		Status - hardware/Status - hårdvara			Project/Projekt
PART/ARTIKEL		ENVIRONMENTAL CHARACTERISTICS/MILJÖKARAKTÄRISTIK			RATING/VÄRDERING					
No./ Nr	Impact phase/ Påverkansfas	Activity/ Aktivitet	Environmental aspect/ Miljöaspekt	Environmental impact/	S	Sd	Ip	POT	Recommended action/ Rekommenderad åtgärd	Decided action/ Beslutad åtgärd

Fig. 1 A selected section of the environmental impact evaluation form

the organization shall determine the environmental aspects of its activities, products and services that it can control and those that it can influence, and their associated environmental impacts, considering a life cycle perspective. p. 9 [23]. Additionally, resource efficiency has increasingly become the focus of European initiatives (e.g., the EU's circular economy package) [24].

Therefore, it had been identified that the environmental analysis had to be considered in all PD projects, but to be able to make this happen, the tool had to be easier and faster to use. A reference group was put in place to develop and approve the environmental screening tool. It was also acknowledged that the connection between PD and production could be improved. The improvement work was mainly done during 2015, together with the reference group with participants for PD and production from the different parts of Volvo Group. This reference group was important, since they had an opportunity to influence the development process of the environmental design tool. As opposed to EIA, EnvS will need to be regularly reviewed and updated to secure that the most important environmental risks are covered.

Moreover, in the effort to adapt ease of use and beneficial outcomes, two Environmental Screening (EnvS) tools were developed, one for PD and one for production, with a link in-between, so if a new component affected Volvo Group production, the checklist for production would be filled in. The EnvS for PD is a tool for collecting answers to all known, relevant environmental questions that are important for PD. It may be so that another tool needs to be used to be able to answer a question, [e.g., if a question regards Design for Recycling (DfRecycling)]. To be able to answer if a new part will be designed for recycling, the DfRecycling checklist may have to be completed. The EnvS for production is a checklist on its own, with no extra checklists to consider for answering the questions. For PD, it is important that the start-up meeting is held early in the development process. If it is held before a supplier is chosen, then requirements can more easily be added to the supplier. The two EnvS tools have been tested and further developed in pilot studies. During the pilot studies the enthusiasm from engineers was also crucial in developing the tool, since they expressed their desire to make a difference.

4 Discussion

The first research question can be answered by how Volvo Group established a reference group from different departments that also included users of the tool. The case study also highlighted the importance of carrying out a pilot study for useful feedback and refinement of the tool.

Regarding the identification of organizational needs and the determination of how to manage them in order to adapt or create a tool to address environmental performances, the case study showed that the context plays an important role not only in shaping company's core values, but also in its operations, use of tools and ultimately decision-making. In this case study, the organisational needs were

identified by the manufacturing department as well as the engineers wanting to make a difference. It also became clear that communication between design and manufacturing had to be enhanced, and that a tool in the form of a checklist could help in strengthening that communication.

Finally regarding the identification of users, involved actors, inputs and useful outputs that tools need to consider and/or provide in order to support decision-making in the early stages of design, the EnvS tool(s) at Volvo Group identified the users of the tool as personnel from the manufacturing, engineering, purchasing, aftermarket and styling departments. The inputs for the tool came from external and internal sources, an example being the increasing awareness of environmental impact and enthusiasm from the engineering department to change the status quo.

The outputs are then useful for analysing decisions and acting on them. Information from a Design for Remanufacturing (DfReman), Design for Recycling (DfRecycling) or LCA study are some of the inputs to the EnvS checklist then providing outputs for actions such as choice of concept improvement of supplier demands and compliance with ISO 14001. It also illustrates that a checklist can serve the purpose of addressing both design and management decisions.

In order to illustrate how the checklist supports decision-making, the following diagram shows the different inputs, outputs, purpose and decision-making (actions) of the checklist. This is depicted by using the PDCA quality cycle, which stands for Plan-Do-Check-Act [25] (Fig. 2).

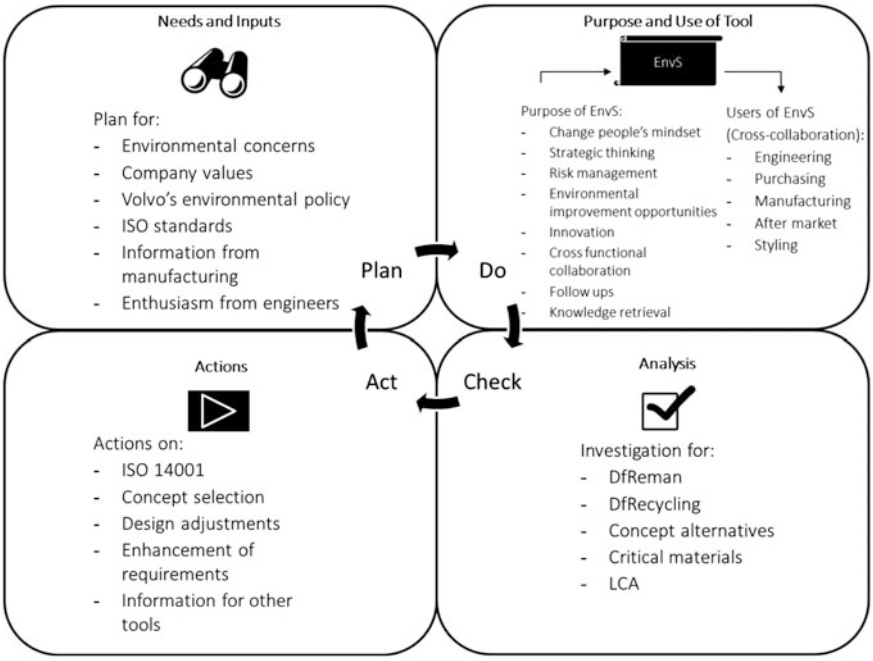


Fig. 2 The impact of environmental screening on decision-making

5 Conclusion

This methodology development, presented through a case study, showed how an organisation in the transport sector has developed a checklist named Environmental Screening (EnvS) in production and product development. From the analysis of the case study, important conclusions can be drawn.

These can potentially help interested readers in their own design and implementation of environmental tools, and can be summarised as follows (in no specific order):

- Carrying out a pilot project in order to get feedback and refine the usefulness of the tool is advisable.
- Enthusiasm from workforce for buy-in and feedback can help in developing the tool.
- A facilitator with deeper knowledge can operate the tool and simplify complexity arising from multiple stakeholders and levels of knowledge.
- A reference group consisting of relevant people from different departments and potential users of the tool are important to consider.
- A tool should match and reflect company values for easier incorporation into every day operations.

It is also important to mention that this research has some limitations. The use of a single case study presents a particular example in industry. However, this research can stimulate discussion and an exchange of experiences from organizations facing similar challenges towards sustainability.

The results of this research can be insightful for companies that want to incorporate environmental tools into their design, operations and product development. They could potentially use this research when developing tools of their own. Academics that do research on design and implementation of methods can also benefit from this study. They can find and compare similar needs in other organizations and identify factors to be considered when developing tools and validating them. Finally, future work could address tools for earlier stages in design (fuzzy front end) and other sustainability aspects that can provide an insight into how needs are identified and addressed.

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