CSR Managing Sustainable Product Development

With a Case for Passenger Vehicles

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1 Introduction

1.1 Sustainable Product Design and Development

Sustainable product design aims in merging good design and sustainability.

Design has in particular the dimensions of function and aesthetics (ratio and emotions). Good design is the prerequisite for market success as often only an emotional design attracts customers – in particular looking at luxurious products. Good functionality of a design is important for the use intensity of the product. Aesthetics should follow function or vice versa – depending on the perspective.

Sustainable development is defined by meeting 'the needs of the present without compromising the ability of future generations to meet their needs' (United Nations, 1987). Normally, this approach refers to three dimensions – environmental, social/societal and economic. Other definitions mention 8 or more dimensions of sustainability - physical, properties, environmental, economic, social, equity, cultural, psychological, ethical (Bossel, 1998). However, also the organisational aspects are of importance.

Sustainable Product Design is a subset of a broader approach towards a Sustainable Product Development that looks beyond product design aspects also at other strategies to improve the sustainability of meeting needs – by products, services and/or organisational aspects. Available strategies can base for example on the following concepts:

- Classical Design-for-X (with X = Disassembly, Recovery, Environment) or Cradle-to-cradle design or sustainable product design.
- Product Service Systems.
- Sustainable Life Cycle Management.

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1.2 Sustainable Mobility

Depending on the type of need the focus is on one or the other solutions. For the area of sustainable mobility solutions may be found in three areas:

– Technology
– Systems & Infrastructure
– Behaviour.

Technology aspects relate for example to further improved high tech gasoline and diesel engines, flexible fuel vehicles (FFV) or other alternative fuelled vehicles, hybrid solutions or long-term fuel cell vehicles. All these technologies aim at further reducing CO_2 emissions from vehicles. Also other Design-for-X solutions are mainly technology-related.

System and infrastructure aspects include for example the density of filling stations for modern fuels. Also social and environmental supply chain aspects have a striking role. Service approaches as mentioned earlier are system related solutions.

Behaviour related aspects can be best explained looking at the huge potential of a driving pattern that is safe and fuel efficient.

The three mentioned sustainability mobility solutions can be applied to all life cycle phases of mobility. Each life cycle stakeholder group has specific roles and responsibilities in order to achieve more sustainable performance. The paper provides examples of these roles and responsibilities of life cycle stakeholder as part of a Life Cycle Management (LCM) concept. One aspect for automotive manufacturers besides innovations is also the day-to-day management of product development. The paper is detailing in particular the latest approach of sustainability management within product development based on the Product Sustainability Index (PSI).

2 Sustainable Life Cycle Management

2.1 Fundamentals

The fundamental idea of sustainable life cycle management is the concept of a shared responsibility of all life cycle stakeholders. Along the product life cycle different stakeholders have opportunities to improve social, economic and environmental aspects. All stakeholders have up-stream and down-stream partners. The resulting interfaces can be utilised to provide incentives for life cycle partners to improve their performance. Part of this concept is to look for most efficient solutions along the life cycle. This can be done based on tools addressing the dimensions of sustainability (Life Cycle Assessment, Life Cycle Costing and Social Life Cycle Assessment; see http://www.life-cycle-management.eu).

Table 1 lists the roles of the direct life cycle stakeholders to improve the environmental, social and economic performance of products and services. This sustainable life cycle management can be initiated by each of the life cycle stakeholders. While big corporations may have advantages in organising life cycle management (purchasing power, available resources, lower dependency on few consumer) in reality also small companies have their opportunities (lower number of products, processes and departments, faster and better internal communication, easier decision structure).

Table 1: Role of life cycle stakeholder to improve the environmental, social and economic performance of products and services – based on (Schmidt, 2001)

	Role of industry (manufacturers and suppliers)	Role of consumer (users / end-users)	Role of companies in the disposal / recovery business
Up-stream in the life cycle	Sustainable Supply Chain Management (social & environmental minimum standards)	Purchasing sustainable products (fair trade, green products) accepting premium.	Information to end-user
Own life cycle stage	DfE / cradle-to-cradle design, Sustainable design, environmental management, social standards, corporate citizenship	Sustainable use / consumption, following use instructions, minimise consumption of energy & materials	Establishing sustainable recovery routes generating competitive products
Down-stream in the life cycle	Product information & training, sustainable dealer standards	Directing products and materials to the appropriate collection / disposal / recovery facilities	Information to producers, sustainable supply of recovery products.

DfX = Design for Environment

Note: simplified table – other, indirect stakeholders (for example investors, banks, research institutes) have also roles to provide incentives for the listed direct stakeholders (for example by providing capital for sustainable investments).

2.2 Examples of passenger vehicles

There exist numerous examples for each of the entries in Table 1 – some of them detailed in (Schmidt, 2001). For example, the development and mass production of sustainable propulsion technologies, offering the necessary fuel infrastructure (fuel development & filling stations), safe eco-driving (Hennig 2001) and the generation of recyclates. However, the efficiency of these measures is quite different (Table 2).

Table 2: Efficiency of exemplary actions of different life cycle stakeholder for passenger vehicles

	Propulsion technique 1	Eco-driving	40 kg recyclates*
Life Cycle Global Warming Potential	- 15%	- 25%	- 0,03%
Summer Smog Potential	- 20%	- 30%	Close to zero
Life Cycle Cost	- 1 %	- 5%	Close to zero
Other Impacts	Image	Safety, drive-by-exterior noise	Use of sustainable materials

* It is not suggested that it is reasonable to introduce 40 kg recyclates in passenger vehicles.

Obviously, the main stakeholder impacting important environmental, social and economic parameters is the consumer. But also the team work of different stakeholders is crucial. This can be best demonstrated looking at alternative fuelled vehicles that need the support by the vehicle producer (offering these vehicles), fuel supplier (work on alternative low carbon fuels and ensure widespread availability of these fuels to the consumer) and consumer (accepting premiums and a maybe lower density of filling stations, applying eco-driving). Such an integrated approach is the best way to efficiently and effectively improve key impacts of vehicles.

The example of passenger vehicles can illustrate also the important role of governments shaping in particular consumer purchasing and driving behaviour in a more sustainable way. For example, tax incentives for vehicles with improved environmental performance (for example CO_2 based taxation schemes) are often necessary to generate a sufficient market demand for these vehicles. However, to avoid market distortion these incentives should not be technology prescriptive – for example preferring vehicles using a certain alternative propulsion system (for example full hybrid vehicles) while conventional propulsion technologies (gasoline, diesel) can achieve the same objective. It is also crucial that policy makers create a reliable, non-contradictory framework where different regulation is do not cancel the effects of each other.

3 Sustainable Vehicle Design

3.1 Context of Sustainable Vehicle Design

The concept of a shared life cycle stakeholder responsibility is not meant as a proposal that stakeholders have no unique roles for their own life cycle phase. However, the description of the concept of sustainable life cycle management serves as a description of the broader context of sustainable vehicle design.

Besides the general positioning of sustainable vehicle design within a sustainable life cycle management also the organisational context has to be clarified. It is of utmost importance in complex, big corporations to make the individual departments / organisations directly responsible for that specific aspect of sustainability that can be impacted by their area of responsibility.

Main affected departments include Product Development, Manufacturing but also Human Resources and External Affairs. Each main functional group translates the meaning of sustainability to their own area. This is the best way to allocate understanding, ownership and responsibilities in a complex organization. In the case of automotive products Product Development needs very long lead times, longer than any other of the above mentioned functions – changes in methods take several years to trickle through buy-in, cycle planning, kick-off, development and launch. PD also has a greater impact on automotive products compared to other organisations of automotive manufacturers.

Sustainable vehicle design is a challenge looking at the complexity of the passenger vehicles where engineering management as well as design engineers need to cope with a global supply chain, a as well as thousands of technically challenging components linked with sever quality, technical, process and infrastructure constraints. This requires a company-specific solution rather than a one-size-fits-all approach. One of Ford of Europe's solutions for managing a sustainable product development is the Product Sustainability Index (PSI).

3.2 Ford of Europe's Product Sustainability Index (PSI)

While there is so far no international standard for measuring the product sustainability there is a common understanding that life cycle thinking should be the basis of such an approach (VDI, 2006). Therefore, the chosen PSI indicators are partly based on ISO14040 (Life Cycle Assessment) and the current work of SETAC Europe on Life Cycle Costing (SETAC, 2006). Part of the additional guiding principles for the inclusion of indicators in the PSI had been the following management directions (Schmidt and Taylor, 2006):

– Key environmental, social, and economic vehicle attributes only
– Controllable (mainly influenced by the Product Development department, not by other functions).
– No additional data need (regular status tracking possible based on readily available product development data).
– Bottom-line issues only (no technologies as alternative fuels but the overall life cycle impact).
– Reduce to a manageable amount of indicators.

PSI is not reduced to a single score as sustainability is by definition not one-dimensional but always measured by different indicators. Further reasons have been shared in a previous paper (Schmidt and Sullivan, 2002).

Other sustainable mobility aspects - in particular service aspects - are not covered as not appropriate on the engineering level. Also legal compliance issues as recyclability are not covered within PSI as these are base line requirements. Some recycling requirements may not even add environmental benefits as outlined in a previous paper (Schmidt et al 2004).

The resulting PSI indicators are (Schmidt and Taylor, 2006):

– Life Cycle Global Warming Potential (Greenhouse emissions along the life cycle – part of an LCA according to ISO14040)
– Life Cycle Air Quality Potential (Summer Smog Creation Potential (POCP) along the life cycle (VOCs, NO_x) – part of an LCA according to ISO14040)
– Sustainable Materials (Recycled & natural materials. Note. All materials are linked to environmentally, social and economic impacts and cannot be inherent sustainable. However, recycled materials and renewably grown, natural fibres represent a kind of role model how limited resources can be used in a sustainable way. Overruling is the question whether these materials have – in their specific application –a lower environmental impact along the product life cycle compared to potential alternative materials)
– Restricted Substances (Vehicle Interior Air Quality / allergy-tested interior, management of substances along the supply chain; 15 point rating).
– Drive-by-exterior Noise
– Safety (pedestrian and occupant)
– Mobility Capability (Mobility capacity (luggage compartment volume plus weighted number of seats) related to vehicle size. This is an indicator in transition towards an indicator covering also aspects of providing mobility services to disabled)
– Life Cycle Ownership Costs (Vehicle Price + 3 years fuel costs, maintenance costs, taxation, insurance minus residual value).

The implementation of PSI has been done in a process driven, top-down approach. Process-driven, as PSI has been linked in the existing Ford Product Development System from the very beginning. For example, Ford's PSI is included in particular in the companies' "Multi-Panel Chart" where all vehicle attributes (craftsmanship, safety, environment, costs, etc.) are tracked, through all the development milestones, against the approved vehicle program targets. Vehicle Integration engineers have been made responsible by the specific vehicle program management to track the performance of the vehicle against the targets. The PSI targets are determined from already existing targets as listed in other sections of the "Multi-Panel Chart" (e.g. fuel economy) as well as PSI specific targets not covered otherwise (e.g. related to the maximal impacts from the selected materials). PSI reflects the overall impact of the different vehicle attributes and makes the trade-offs visible (e.g. between life cycle global warming potential and the life cycle cost of ownership).

In a top-down approach, senior management demanded and finally authorized PSI in autumn 2002. The roles & responsibilities have been agreed in a way that mainly all actions and responsibilities are conducted by Product Development itself without using a central staff organization (exemption: development of methodology). This way, an optimal integration of PSI is ensured – i.e. sustainability is not the responsibility of specialists (within or outside Product Development) but is executed by the same people running other aspects of the vehicle development.

A comprehensive but very simple spreadsheet file has been developed by a Ford LCA specialist to enable non-specialists to track PSI. This tool has been verified against detailed ISO 14040 external reviewed LCAs (Schmidt and Butt 2006). Based on the central input of few and select data, the PSI – including the simplified Life Cycle calculations – are tracked from the very beginning of the vehicle development throughout its end. Almost all data used had been anyway readily available in the above mentioned "Multi Panel Chart". Few additional data have been needed (for example any material changes and data about air-conditioning systems). With around 1 hour training, the responsible engineers have been in the position to understand the concept, use the above mentioned file and conducting simplified Life Cycle avoid unnecessary bureaucratic burdens or the need for additional resources while ensuring that sustainability is an integral part of the complex product development process.

The described approach is designed to fit perfectly to the Ford design processes and culture. It is not suggested that this approach necessarily fits to other company cultures or markets as the methodologies and approaches cannot be generalized. Any mandatory approaches would be counterproductive. Sustainability can only work based on internal understanding, drivers, motivations and commitment rather than law and order. PSI is a voluntary approach aiming at integrating environmental, social and economic aspects in the product development as part of Ford's commitment towards sustainability and creating dialogue around these issues.

3.3 PSI application for Ford Galaxy and Ford S-MAX

The first design team that used PSI from the beginning developed the new Ford Galaxy and Ford S-MAX. Four vehicles have been assessed:

– New Ford Galaxy 2.0 l TDCi with DPF Trend edition,
– New Ford Galaxy 2.0 l, Trend edition,
– New Ford S-MAX 2.0 l TDCi with DPF Trend edition,
– New Ford S-MAX 2.0 l, Trend edition.

Note: DPF = Diesel Particulate Filter

The environmental, economic and social performance has been compared to the prior Ford Galaxy (1.9l TDI, 96 kW, manual 6 speed version). Within Vehicle Integration engineers have been made responsible for tracking the status based on the input collected in the "Multi-Panel Chart" and few additional key data specific for PSI. The additional PSI data related to the material breakdown of the different vehicles have been derived from complete teardown data of the predecessor models, weight assumptions as well as weight actions and finally International Material Data System (IMDS) data. Towards the end of the development, an additional verification study has been performed by a corporate LCA specialist. The PSI, as well as the internal verification study, has been successfully reviewed by two external reviewers – Professor Dr David Hunkeler (former Universities Vanderbilt in Nashville/USA and Lausanne/Switzerland) and Prof Dr Walter Klöpffer (University of Mainz/Germany) - according to ISO 14040. One of the important findings has been that the life cycle calculations done by the non-experts based on a simple spreadsheet file are fully in line with the results of a more detailed study performed by the LCA expert based on an expert tool (IKP and PE, 2005) (calculated absolute figures are less than 2% below; the relative results are the same).

The PSI application itself (without expert verification study and external review that are not necessary for the internal usage of PSI as a sustainability management tool) is done efficiently. Due to the focus on available data as well as a simple spreadsheet file the incremental resources needed for the management tool itself has been rather low (approx. 10 –15 hours for the whole product development process). However, the efforts for the verification study and the external review are much more significant. This has been only done in this specific case because Ford Galaxy and S-MAX have piloted the PSI application. The verification study allowed to get a better confidence about the accuracy of the PSI calculations while the external ISO 14040 review allowed the publication of the taken efforts.

The PSI status has been tracked for different Gateways (Kick-off (KO), Program Approval (PA), Program Readiness (PR) and Change Cut-off (CC)). Table 3 summarizes the results for the studied diesel powered Ford vehicles.

4 Summary

Managing a sustainable product development is a challenge including and beyond managing the design in a sustainable way. Ford of Europe's Product Sustainability Index (PSI) can be seen as an example for a sustainability management tool that efficiently guides the development of passenger vehicles. However, this is only one tool in a set of tools covering the different functional areas of an automotive manufacturer.

In addition, an integrated approach is necessary to gain additional improvement potentials. This sustainable life cycle management is a central approach to efficiently improve the environmental and socio-economic performance of products as passenger vehicles.

Table 3: PSI results of diesel powered Ford Galaxy and Ford S-MAX

Indicator	Previous Ford Galaxy 1.9 L TDI	Ford Galaxy 2.0L TDCi with DPF	Ford S-MAX 2.0L TDCi with DPF
GWP [t CO2-eq] (1)	41	40	39
POCP [kg Ethene-eq] (1)	39	37	37
Sustainable Materials (note: figures may change)	Approx 1 kg	Approx 18 kg	Approx 18 kg
Restricted Substances	Substance management, pollen filter	Substance management, TÜV tested pollen filter efficiency and allergy-tested label (2)	
Drive-by-exterior Noise dB(A)	73	71	71
Safety	Reference (3)	Significant improvement (4)	Significant improvement (4)
Mobility Capability	9,9 m², 7 seats, 330l	10,4 m², 7 seats, 435l	10,25 m², 5 seats, 1171l
Theoretical Life Cycle Ownership Costs (5)	Reference	5 % lower costs	10% lower costs

(1) based on PSI calculation that have been verified by an independently reviewed LCA according to ISO14040. LCA done based on the methodology and data described previously (Schmidt et al 2004), (Schmidt and Butt, 2006).
(2) based on an independent TÜV certification, certification number AZ 137 12, TUVdotCOMID 0000007407.
(3) including Euro NCAP safety rating: 3 stars for adult occupant protection, 2 stars for pedestrian protection.
(4) including Euro NCAP safety rating: 5 stars for adult occupant protection, 4 stars for child protection and 2 stars for pedestrian protection.
(5) 3 years Cost of Ownership including residual value, no guarantee.

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