Reducing Conflicts of Interest in Eco-design: The Relation of Innovation Management and Eco-design in the Automotive Sector

Therese Elisabeth Schwarz, Kerstin Schopf, and Astrid Arnberger

Abstract Product development lately has to deal with economic, technical, consumer-related and environmental issues. Environmental concerns owed to changing climate, local natural catastrophes and lack of resources are pushing into the foreground. Eighty percent of a product's environmental footprint is determined in the design phase. Eco-design, integrating environmental matters while improving the environmental performance, is familiar to industries but rarely applied, hemmed by various barriers and obstacles. Conflicts of interest emerging in the R&D phase impair considering and enforcing a switch to eco-design. Conflicts are produced by different legal and normative frameworks, aims of corporate departments or product requirements. A closer look at two life-cycle phases (product development and end of life) helps understand eco-design in automotive battery development.

Keywords Eco-design • Future waste • Innovation • Management • Batteries

1 Introduction

Keeping an eye on life cycles turns the R&D phase of products and associated processes into a challenge to companies and their suppliers. Characteristics of emerging product lines also cover environmentally compatible design, besides economic efficiency and functions. Requirements of target groups and the framework of standards force companies to improve their competitiveness on the market. To handle this, innovation management is integrated in the company's strategic framework. But eco-design is not. Why not?

T.E. Schwarz (✉) • K. Schopf • A. Arnberger
Chair of Waste Processing Technology and Waste Management, Montanuniversitaet Leoben, Leoben, Austria
e-mail: therese.schwarz@unileoben.ac.at

M. Matsumoto et al. (eds.), *Sustainability Through Innovation in Product Life Cycle Design*, EcoProduction, DOI 10.1007/978-981-10-0471-1_3

2 Eco-design in Strategic Management

Johannson [1] describes eco-design as reducing the environmental impact of a product's life cycle while preserving or even improving other attributes like price and function. So the aim of eco-design is to streamline a product in various directions.

The purpose of this paper is to discuss the extensive introduction of the principles of eco-design in strategic and innovation management. Basic methods applied in both management areas are reviewed and transferred to the automotive battery production sector, used as a case study.

Strategic management, being a part of business economics, is closely tied to product policies and the main goals of a company. It aims at an encompassing view of a company, while eco-design strives for an encompassing view of a product. Various methods used in the field will be considered and discussed in the following, focussing on eco-design.

An important tool of strategic management is SWOT analysis. Four main targets are addressed: strengths, weaknesses, opportunities and threats [2].

A company's strength, as it emerges from supporting eco-design, might be identified as a public image of taking environmental care and setting goals for sustainable product design, ranging from the senior management down to individual projects. It aims at a cooperative relationship with stakeholders and a detailed internal and external information exchange concerning environmental topics [1]. Some internal or external drives for eco-design may be found in almost every sector: reducing costs, better quality, the company's image, committed staff, environmental benefits, corporate governance, requirements of the market and social responsibility [3].

This multi-stakeholder and multidimensional process implies various conflicts of interest between departments, product characteristics and methods. The 'eco-design' topic may be interpreted by departments and their teams in different ways (weakness). Conflicts emerging from product development are the greatest challenge to designers. Eco-design recommendations have to be analysed for safety, quality and proper functioning of different product life stages. Any conflicts should be discussed by experts or intended tools be applied to support decision-making and prioritisation. As a consequence, familiarity with eco-design features, rules and goals is an essential starting point for promoting these innovative approaches.

Opportunities for effective product development are the individual legal and normative provisions that establish a framework for supporting activities in eco-design and promoting companies that are already practising them. Legal regulations are applied to ever more product groups, making the producer accountable not only for matters related to end-of-life topics but also for the extraction, treatment and usage of raw materials. The Directive 2005/32/EC emphasises various energy-relevant matters like conserving energy by stand-by processes, lighting, external power supply, etc. This includes the organisation, such as taking responsibility for environmental data and safe handling of products by importers, benchmarking or CE labelling [5]. Other product group guidelines for eco-design have been derived from this directive. The European Directive 2006/66/EC covers the responsibility of the 'batteries and accumulators' product group [4]. These and other frameworks have inspired manufacturers to take recycling and end-of-life costs into account which they have to pay in advance. The European Union intends to reduce the overall consumption by 365 TWh – a full 12 % of the EU's total power consumption in 2009 [6].

Eco-design is often considered a 'welcome secondary benefit'; therefore, buyers do not want to pay for its more expensive development. Developing 'green' products has remained a market niche of the automotive industry for the last few decades. Concerning references on management, 'Porter's five forces' [7] emphasise the threats companies are exposed to, affecting both the market share and the corporate environment. These four threats create opportunities for flexible and innovative companies: (1) Threat of new market entry, (2) substitution, (3) buyer and supplier power and (4) competition. Battery-powered mobility and especially battery development are very competitive markets although only a few battery-powered vehicles have been sold so far. This competitive environment is stimulated by battery manufacturers entering the automotive market (threat of new market entry).

Another phenomenon is substitution. Products that do not excel against competing products tend to drop out of the market. With regard to batteries, cell chemistry is their essential characteristic. Lithium-ion batteries are favoured by R&D against other chemistries because of their higher intensity and current. Modern compounds like lithium-cobalt-oxide (LiCoO 43 %), lithium-nickel-manganese-cobalt-oxide (NMC 32 %) and lithium-manganese-oxide (LMO 11 %) are widespread [8]. Metal-air chemistry and different kinds of alternative fuels (fuel cell, natural gas, etc.) will be closer considered in the future [9]. As a result, focusing on the development of only one power-generating system limits the access to future automotive markets.

The balanced scorecard is a tool for measuring the performance that has been developed by Kaplan and Norton [15]. Its purpose is to assess four different performance categories and to combine them in a possible future analysis. The financial view involves different business indicators relevant for the shareholders. Other parameters of the tool cover customer and corporate views. Corporate processes and customer satisfaction are analysed. The 'organisational learning' category gives an outlook on the future and ties to social innovation. The non-market view and the sustainability assessment that have been added to the original parameters at a later stage include further characteristics to obtain an encompassing insight into the company's performance. Figure 1 shows how the environmental parameter is integrated in the present categories and allows analysing economic and other quantitative factors [16]. Concerning eco-design, the goals of product development should be entered in the individual categories. A non-market-related goal might be to reduce greenhouse gas emissions of the next generation of batteries by 10 %, or a financial goal might be to decrease cost by saving on material and energy during the production. This is the foundation on

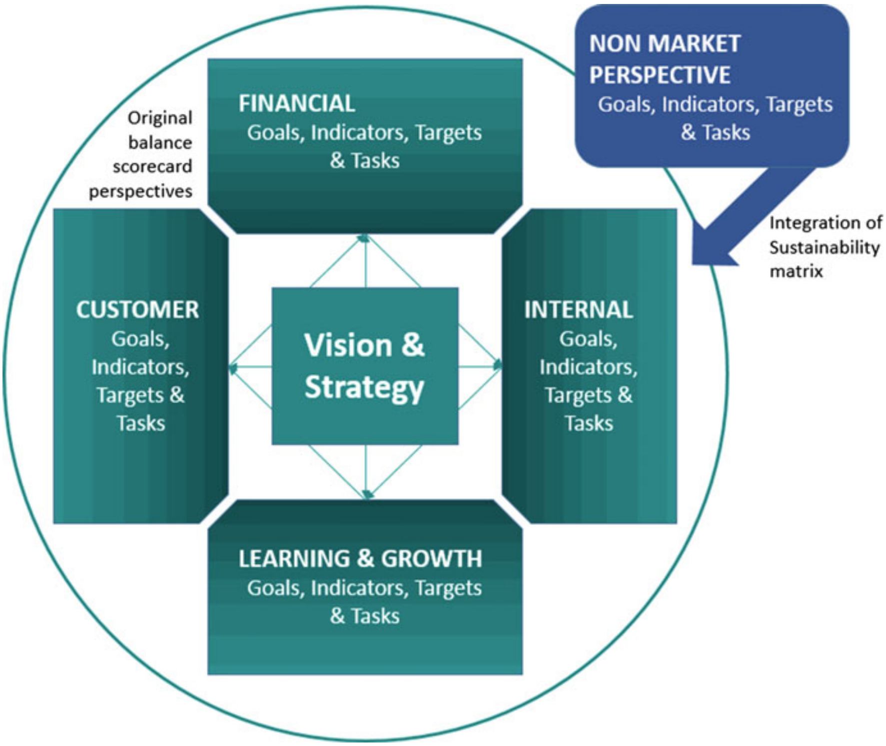

Fig. 1 Balanced scorecard with integrated sustainability (According to Ref. 16)

which concise goals, indicators like energy-saving targets and tasks for implementation, are defined. The balanced scorecard with added sustainability shows options for how to introduce environmental goals in management, much like other business targets.

Senior management and PICs should accordingly define environmental goals for the company and its projects. The environmental matters should be integrated in the corporate strategy and be treated and rewarded like any other business subjects. On the project level, environmental milestones support commitment and priorisation. A workshop should be run by an external moderator and involve an eco-design expert lobbying environmental tasks. Another important matter is the multidimensional and interdisciplinary thinking of all project members and their commitment to innovation and change [1].

References reveal that environmental issues and the supplier chain management are changing courses as new performance indicators, control systems and data requests are implemented [12].

Buyers and final-product manufacturers significantly affect the development of products. The original equipment manufacturers (OEM) in the automotive industry ask suppliers (of all levels) to report the compositions down to their elements. Parts data, construction plans and other relevant information are uploaded to the

International Material Data System (IMDS) [10] that is synchronised with the Global Automotive Declarable Substance List (GADSL) [11]. Recovery concepts, life-cycle data and measures to reduce energy (fuel) consumption are required. Such control mechanisms force companies to establish data collection systems and to consider all life-cycle phases (which is another opportunity for eco-design).

Collaborating with suppliers and experts on environmental concerns can help achieve an interactive development of products beyond a mere specification sheet. The main task is to inform suppliers about criteria and activities needed for eco-design and to simplify and customise the tools for everyday use [1]. Designing an environmentally compatible product implies collaborations with stakeholders and the supplier management as an essential part of components design. Skills and experience of corporate staff should reduce any direct environmental impact that may occur during the life cycle and resulting problems with designing. Evidently, the starting point of the design process in the early development phase should be the smallest unit. Deciding on materials, shape, processes and functions is basic to the very beginning of designing [1].

A couple of interviews and workshops have helped identify the teams that are relevant for decision-making and the design process of a battery pack. It is essential to understand the design process applied in the automotive industry or battery development which is divided into four phases.

1. A-phase: Ideas for the product are collected and initial workshops on the basic customer demands and functions held. A prototype is developed and constructed but often out of parts that have not been obtained from the final supplier, and the ultimate material, shape, etc. may not yet have been defined. The purpose of this prototype is to plan the functions.
2. B-phase: This prototype helps shape ideas in detail. In this phase, meetings with suppliers and decisions about forms and materials are obligatory. A second prototype that includes most of the final properties is produced.
3. C-phase: The process is determined and will be streamlined. Different parts of the battery system are produced, applying mass production procedures, and initial practical use tests are performed.
4. D-phase: The complete battery is made in batch production with all product characteristics. The characteristics are streamlined and additional concepts developed, like after sales or recycling concepts.

Especially in the A-phase, the knowledge and expertise of project engineers, simulation directors, constructers and electric engineers contribute significantly to improve the product. The technical draughtsmen and industrial engineers provide gateways from planning to implementation and should be trained in eco-design methods. Two phases emerge from eco-design decisions: concept and layout design [20]. Innovation management takes a closer look on the corporate procedures of product design.

3 Eco-design in Innovation Management and Product Development

Handling innovation is a basic parameter of developing sustainable products, besides strategic decision-making or market and product policies. From the innovative point of view, factors like technology push or market pull are crucial for making decisions. Every company unit has different methods of how to set, reach and assess its goals. The ability to interact and collaborate is required in any corporate structure. According to Cai and Zhou [13], internal and external drives are creating integrative powers, encouraging eco-innovation. Eco-innovation is defined by the OECD as the result of two characteristics: an emphasis on the environmental impact and the development of products and processes with their life cycle standing in the foreground and another on social innovation and new institutional structures [14].

Innovation management distinguishes incremental and radical innovation. Incremental innovation means inventions related to an existing product that provide little innovative capacity. Some parameters are modified but the functions and basic characteristics remain the same. The second type of innovation is more fundamental: any product characteristics, functions or even target groups may be altered. Usually, these radical innovations are not market pushed: the customers cannot specify their needs and expectations with regard to properties of the new product [17]. Robert Cooper [18] describes the Stage-Gate model that introduces innovation management in common product development. Six different stages have been defined that are separated by gates, each of which is charged with reviewing the previous development process and providing exit options. Repeated reviews of the innovation process could make eco-design a factor in the gate's decision. Including eco-design criteria in the concept will focus on transparent decision-making and the active participation of various interdisciplinary employees. On the other hand, the Stage-Gate process supports the submission of eco-design criteria and goals to other PICs and also forces project members to introduce eco-design into early stages. Eco-design should in fact be integrated in the primordial designing process. Decisions on environmentally compatible products are made in meetings, workshops and the proper designing process (drawing, materials and components). Discussing and informing about life cycles on the approach might contribute here, even though eco-design goals should be isolated and taken very serious by the designers.

Various design areas and product characteristics, like those listed in Table 1, can be integrated in the Stage-Gate process to introduce eco-design criteria into the development phase; see Fig. 2.

Identifying eco-design issues may look easy but is hard to achieve. Topics that cover the main issues of eco-design are suggested by Luttropp and Lagerstedt [19] in an extended checklist; see Table 1. Many other checklists and qualitative tools can help identify critical points at early development stages but often seem to be very unspecific.

Table 1 Criteria for eco-design actions and associated design phase [19]

Eco-design areas in product design	Automotive design phase
Reducing material (weight), energy and resources, material substitution (quality and purity) or surface treatment	A, B, C
Choosing non-toxic and nonhazardous substances	B
Increasing reuse/remanufacturing, recovery, any kind of waste treatment, design for long life and disassembly	B, C
Enforcing the use of renewable materials and the reduction of fuel consumption/transport	B, C
Reducing components and joining elements or excipients	C, D
Promoting structures for easy housekeeping, upgrading and repairing (modular)	A, B, C
Involving life-cycle stages, impact and costs, circular economy (closed loop)	A, B, C, D
Clarifying and identifying materials and streamlining processes and transport	C, D
Adding functions to a product/selling the service	A, B
Enabling the consumer to correctly use and dispose of the product	C, D

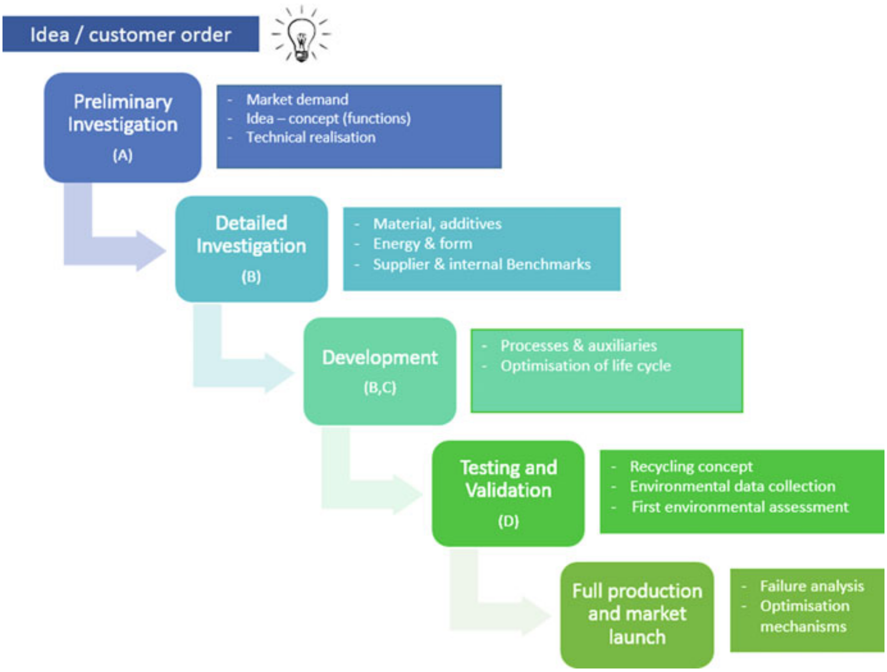

Fig. 2 Stage-Gate process and eco-design (According to Ref. 18)

Hence, methods like life-cycle assessment (LCA) or failure mode and effects analysis (FMEA) are effective tools for detecting environmental hazards on low levels. Even complex product parts can be examined and an encompassing view of the life cycle and any failures, hazards or obstacles be identified before a specific concept is accepted.

Checklists and internet tools, however, can be easily adopted by designers. Obviously, industry tools should be intuitive and flexible yet more precise and customisable than many of the present software tools are. Eco-design tools and checklists need to be customised to match the company's activities and to cover relevant topics and examples.

Even though the eco-design tool is intuitively structured, it ought to be supported by company members. Training employees in eco-design does not prevent conflicts from arising in the development process, and these have to be identified. Potential areas of conflict can be safety/health, quality, mass production, product functions, design issues, legal/normative framework, consumer requirements, financial criteria and marketing or other eco-design criteria. There is often a trade-off, but sometimes, especially when normative and legal requirements interfere, eco-design recommendations have to be withdrawn.

Concerning the design of vehicle batteries, these conflicts of interest may arise from different causes. Looking at the first development phases (A, B), conflicts of interest emerge either from technical solutions, from organisational requirements or from quality parameters. At later stages of the design process, other factors increase: financial aspects, shaping, presentation design, customer requirements, etc. Table 2 shows selected examples of conflicts.

Table 2 Selection of eco-design recommendations and conflict areas

Eco-design rules/criteria	Conflict area examples
Reducing structures – similar joints	Quality – safety requirements warrant, due to different kinds of joints, that production staff will assemble the product correctly and not suffer any injury
Purity of material – facilitating recovery	Product functions – composites are commonly used because of their low weight, stability and other characteristics, but applying several layers means that recovery is difficult and the material should be separated from other components
Streamlined structures – reducing functions	Decisions by purchasing/marketing – purchasing may want to reduce overall costs and decline a supplier with a perfect but expensive component or marketing may request to add a component that improves the look of the product
Using renewable materials	Technology and functions – if renewable materials do not allow meeting the technical requirements
Using non-toxic substances	Mass production and functions – many process steps require toxic substances as adhesives
Design for reusing, remanufacturing and recovering	Safety and functions – components and product parts have to be solidly fixed

4 Eco-design in the End-of-Life Phase

Products that include hazardous and/or a quantity of different substances and have a long life cycle (causing more future amounts of waste) are defined hereafter as 'future waste'. These product groups may have complex structures that prevent their submission to material recovery treatment. A few examples are vehicle batteries, solar panels, wind turbines, etc. [21].

The European Union is setting higher quotas for the recovery of 'future waste'. The end-of-life vehicle Directive 2013/28/EU by the European Parliament and Council [22] stipulates reuse and recovery targets. Since January 2015, at least 95 % of the average mass of all end-of-life vehicles per year must be recovered or reused. According to the current legislation, a removed battery is classified as recovered. Incineration does not constitute material recovery here but energy recovery. The stipulated recovery quotas for the whole car define percentages of material and energy recovery.

These legal constraints place a stronger focus on battery parts. The recycling quotas for different battery types, covering material recycling without incineration, are listed [23]:

- Sixty-five percent for lead-acid batteries
- Seventy-five percent for nickel-cadmium batteries
- Fifty percent for other battery types

The European Regulation 493/2012 defines the recovery of batteries. A clear definition of the battery parts included in the calculation should follow, however [24].

Latest high-tech innovations are more complex than before, due to an increasing number of included functions, substances and design requirements. Battery packs for cars, motorbikes or bikes consist of different modules of power cells, electrical components, cables, housing, cooling and many other parts.

The main parts of a battery are the cells – according to the size and task of the battery, there may be less than ten cells or more than 8000. Different compositions and shapes (prismatic, cylindrical or pouch shaped) demand different requirements from eco-design. This paper is not meant to discuss the design and properties of cells; however, this part contributes a lot to environmental loads, especially in the production and recycling phases.

When designing a product that ought to be recoverable, the proper materials have to be decided about. Metals have a high economic value and contribute much to a battery pack (housing, cells). The main problem with recovering metals is how to purify the input fraction or at least to obtain a composition that the industry accepts. Like, a merger of aluminium and steel implies a loss of value and difficult separation. Another important group of components are electronic and electric parts: besides metals, polymers like polyamide contained in electronic and electric equipment are substantial secondary raw materials that should be recovered to reach the recycling quota. Furthermore, different output fractions (electrolyte, critical raw materials,

Table 3 Material compositions and component groups of the battery systems of different electric vehicle types (Data: battery producers)

Material	PHEV	Motorbike	Bike
Aluminium	16.1 %	26.2 %	10.7 %
Steel/iron	13.4 %	1.3 %	2.1 %
Copper	2.7 %	1.6 %	3.2 %
Cells	58.9 %	60.7 %	71.0 %
Electronic parts	Included in other categories	1.9 %	7.2 %
Plastics	2.3 %	7.6 %	5.7 %
Others	6.6 %	0.7 %	0.0 %

etc.) cannot be treated to obtain high-quality fractions for battery-to-battery recycling.

Table 3 shows different materials and components and their composition. The following data have been collected from various research projects performed by the Montanuniversitaet Leoben. The size of the battery and its number of cells determine the vehicle type; however, decisions about the materials are distinct from each other.

Integrating pouch cells (covered with a plastic envelope) reduces the share of metals. On the other hand, manufacturing processes may also predetermine the use of materials. Welding, adhesive bonding or screwing demand distinct excipients. Altogether, the materials of a battery produce direct and indirect emissions.

The chemistry of cells is not the subject of this paper. Labelling its chemistry, plastics and metals would increase the recyclability and help prevent quality and safety problems emerging from recovery.

The varying constructions, shapes, numbers and compositions of batteries may mean trouble for a common eco-design or recovery concept. Table 4 compares different kinds of batteries and their characteristics.

Various battery constructions impair the recovery of secondary raw materials and energy. Considering how the product may be disassembled for recovery can help understand the problems of repairing, reusing and remanufacturing and even provide important suggestions for future product generations.

The International Disassembly Information System (IDIS) [25] shows disassembly methods for different cars. The main purpose is to remove plastics, batteries and other parts that may interfere with subsequent treatments like shredding. How to disassemble the batteries after separation is not discussed in any detail, though. To cover this subject, various research projects managed by the Montanuniversitaet Leoben have aimed at developing an improved disassembling concept for selected batteries. It had been essential to apply a bill of materials (BOM) and different tools for separation, testing and recording (hammer, screwdrivers, voltmeter, cameras, etc.). First, every step has been recorded by two cameras taking video and image frames, including background data like time required, tools, the sequence of disassembly and the safety equipment. The disassembly experiments have been assessed in (1) a presentation with description, photos and videos of each step; (2) a

Table 4 Battery characteristics (Data: battery producers)

Comparison of different battery types	PHEV 1	PHEV 2	EV 1	EV 2	E-motorbike	E-bike 1	E-bike 2
Battery technology (chemical)	LFP	LFP	NMC	LMO	NMC	NK	NK
Weight [kg][a]	100	120	250	290	25	4	4
Modules	4	3	5	48	3	1	2
Cell type	Metal can	Metal can	Pouch	Pouch	Cylindrical	Cylindrical	Pouch
Number of cells	88	120	180	192	360	70	20
Battery layout	Under the boot	Under the boot	Under seat and floor	Under seat and floor	Under seat	Under seat	Under seat

NK not known, *PHEV* Plug-In Electrical Vehicle, *EV* Electrical Vehicle, *E-* Electrical
[a]Rounded values

spreadsheet containing information on disassembly levels, separation procedures, joints, masses, etc; and (3) a disassembly tree showing the sequence of disassembly. Labelled disassembly points in the battery pack may warrant safe and quick disassembly.

Another important eco-design factor is the procedures involved. Not only production but also recovery procedures have to be considered. Note that manufacturing steps like coating facilitate the production but impair the recovery. A full separation of the materials may not be economically feasible, while a blend of materials cannot be sold on the raw material market. This evidence suggests that eco-design will be successful only if the best compromise is identified and accepted.

5 Discussion and Outlook

Eco-design accesses a life-cycle view of products and includes non-technical and noneconomic issues. Eco-design goals and rules need to be integrated in strategic and innovation management. Combining management methods with eco-design highlights difficulties and obstacles while showing benefits of the idea. This study emphasises a combination of methods and shows its effects on automotive battery production. The purpose has been to define obstacles that hamper the introduction of eco-design and to develop concepts for how to avoid these by using original management tools.

Eco-design in R&D processes reveals conflicts of interest deriving from product characteristics or company departments. These conflicts should be taken into account when eco-design is introduced. Using the adapted checklist to reduce conflicts of interest helps identify the relevant teams and emphasises topics that should be discussed in workshops. Conflicts of interest in different eco-design products will have to be discussed in case studies to derive a complete checklist and a tool to overcome these obstacles. In the case of battery development, the complex product characteristics will often adversely affect eco-design processes.

The Montanuniversitaet Leoben has tried in various projects to make the industry familiar with these efforts. Disassembly experiments and the life-cycle assessment of batteries have shown how product characteristics, structures and processes can be improved. Eco-design may be introduced in companies once available tools are flexible, customised and intuitive and once sufficient know-how and commitment are available (especially on the senior management level).

References

1. Johannson G (2002) Success factors for integration of eco-design in product development. Environ Manag Health 13(1):98–107

2. Harvard Business Review (2007) SWOT analysis. https://hbr.org/product/swot-analysis-i-looking-outside-for-threats-and-opportunities/an/5528BC-PDF-ENG. Accessed 19 May 2015
3. ADAM –European Union projects: innovation and EcoDesign in the ceramic industry. In: ED-IC Ecodesign manual – investigation of the motivating factors for eco-design. URL: https://www.adam-europe.eu/prj/5887/prd/1/4/Tool%201_Motivating%20factors.pdf. Accessed 18 Mar 2015
4. European Union (2006) Directive 2006/66/EC of the European parliament and of the council on batteries and accumulators and waste batteries and accumulators. In: Off J Eur Union nr. L266/1 from 26 Sept 2006
5. European Council (2005) Directive 2005/32/EC on establishing a framework for the setting of ecodesign requirements for energy-using products. In: Off J Eur Union nr. L191/29 from 22 July 2005
6. European Union: adopted eco-design implementing measures to reach energy savings by 2020. URL: http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/product-groups/index_en.htm#h2-2. Accessed 17 May 2015
7. Porter M-E (1979) How competitive forces shape strategy. Harv Bus Rev
8. Avicenne (2012) The worldwide battery market. URL: http://www.kigeit.org.pl/FTP/PRCIP/Literatura/063_The_worldwide_battery_market_2011_2025.pdf. Accessed 12 June 2015
9. Armand M, Tarascon J-M (2008) Building better batteries. Nature 451:652–657
10. International material data system (IMDS). URL: http://www.mdsystem.com/imdsnt/startpage/index.jsp. Accessed 24 May 2015
11. Global automotive declarable substance list (GADSL). URL: http://www.gadsl.org/. Accessed 24 May 2015
12. Srivastava (2007) Green supply-chain management: a state-of-the-art literature review. Int J Manag Rev 9(1):53–80
13. Cai W, Zhou X (2014) in the drivers of eco-innovation: empirical evidence from China. J Clean Prod 79:239–248
14. OECD (2009) Sustainable manufacturing and eco-innovation: framework, practices and measurement. In: Synthesis report. OECD, Paris
15. Kaplan RS, Norton DP (1992) The balance scorecard – measures that drive performance. Harv Bus Rev
16. Möller A, Schaltegger S (2005) The sustainability balanced scorecard as a framework for eco-efficiency analysis. J Ind Ecol 9(4):73–83
17. Strebel H. (2007) Innovations- und Technologiemanagement, 2nd edn. Facultas wuv, UTB
18. Cooper RG (2008) Perspective: the stage-gate idea-to-launch process – update, what's new, and NexGen systems. J Prod Innov Manag 25:213–232
19. Luttropp C, Lagerstedt J (2006) EcoDesign and the ten golden rules: generic advice for merging environmental aspects into product development. J Clean Prod 14(2006):1396–1408
20. Eco-Design Workshop with industry partners, 2015-06-22 in Graz, Austria
21. Pomberger R, Ragossnig A (2014) Future waste – waste future. Waste Manag Res 32(2):89–90
22. European Union (2013) Directive 2013/28/EU of the European Parliament and of the council on end-of-life vehicles. Off J Eur Union Nr. L 135/14 as of 17 May 2013
23. European Parliament and the Council (2006) Directive 2006/66/EC on (waste) batteries and accumulators. URL: http://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=CELEX:32006L0066&from=de. Accessed 19 June 2015
24. European Commission (2012) Regulation on Directive 2006/66/EC on detailed rules regarding the calculation of recycling efficiencies of the recycling process of (waste) batteries and accumulators. URL: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:151:0009:0021:en:PDF. Accessed 19 June 2015
25. International Dismantling Information System (IDIS). URL: http://www.idis2.com/. Accessed 24 June 2015