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HOW TO DEFINE A SUSTAINABILITY DESIGN SPACE

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Abstract

In order for a company to define a sustainability design space and become more sustainable it must know: what sustainability means; how sustainability can be achieved; and, how sustainability can be measured.

The main contribution of this paper is an approach to define the design space for sustainability, with purpose to give support in the early product innovation process. A novel approach is presented for how to identify strategic sustainability criteria, tactical design guidelines and sustainability compliance index that are important parts of a sustainability design space. A case company within the aerospace industry has been chosen to test and validate the sustainability criteria and how it can give support in evaluating the current sustainability profile of a product component by using the suggested Sustainability Compliance Index (SCI).

The result from company feedback and early pilot-testing showed that the sustainability criteria and sustainability compliance index can give support in decisions regarding sustainability perspective in early concept development. The pilot-tests also indicated that there is a need for further development and validation.

Keywords: Design for X (DfX), Sustainability, Decision making, Early design phases

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1 INTRODUCTION

In the state of art paper on industrial sustainability (focus on definitions, tools and metrics), presented by Arena et al (2009) the authors state that in order for a company to become more sustainable it must know: what sustainability means; how sustainability can be achieved; and, how sustainability can be measured? Other researchers conclude that if manufacturing enterprises truly want to support sustainable development, it is important to: have a common view on sustainability (Broman et al., 2000; Johnston et al., 2007); to coordinate and integrate tools and methods for sustainable product development in the overall decision-making process (Boks, 2006; Jorgensen et al., 2006; Hallstedt, 2008; Deutz et al., 2010); to combine widely used initiatives (e.g. life cycle assessment, eco-design, cleaner production and corporate social responsibility) to support corporations in their sustainability efforts (Lozano, 2012); and, emphasize the importance of effective communication (Pujaria et al., 2004).

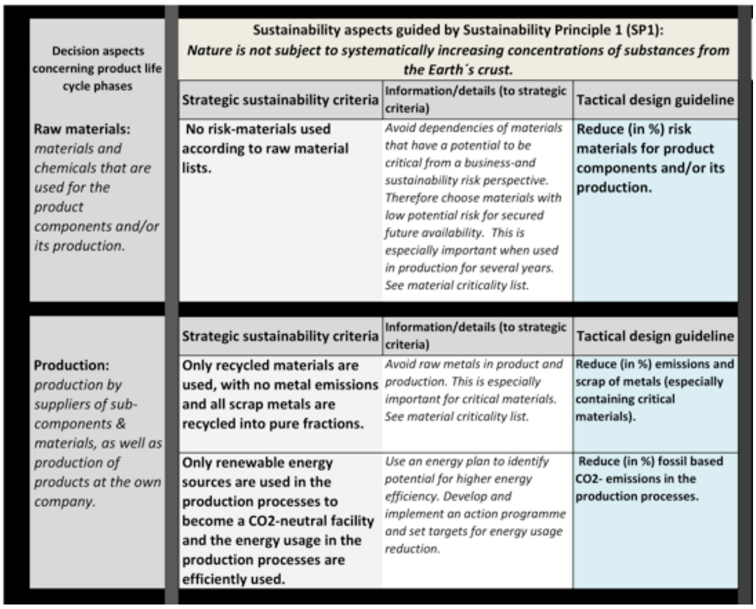
The main challenge addressed in this paper is about how to bring in a sustainability perspective early in the product innovation processes using a backcasting perspective from a definition of success. The main contribution of this paper is an approach to define the design space for sustainability with purpose to give support in the early product innovation process. A novel approach is presented for how to identify strategic sustainability criteria, tactical design guidelines and sustainability compliance index that are important parts of a sustainability design space. A case company within the aerospace industry has been chosen to test and validate the sustainability criteria and how it can give support in evaluating the current sustainability profile of a product component by using the suggested Sustainability Compliance Index (SCI).

In section 1.2 the research approach is explained. Section 2 and 3 gives a more detailed description of the criteria, tactical guidelines and SCI, as well as the approach of defining a sustainability design space. Section 4 presents the results from a pilot test of the sustainability criteria and sustainability compliance index. The last section 5 is a concluding discussion about the design space for sustainability, further application and development of the approach.

1.1 Sustainability Criteria and Sustainability Compliance Index for decision support in Product Development

Sustainability criteria used for decision support in the product innovation process and aligned throughout the design process, is one key element to efficiently bring in a sustainability perspective early in product development. An approach for identifying such sustainability criteria and a process for how these can be developed in any manufacturing company is explained in section 2.2. The sustainability criteria are presented in a matrix, separating the criteria into product life cycle phases and overarching socio-ecological sustainability principles, see an excerpt from such a matrix in Figure 1. The criteria are sorted into long-term sustainability criteria, called strategic sustainability criteria, and short-term criteria (more urgent), called tactical design guidelines. In addition a qualitative measurement scale for the criteria, called Sustainable Compliance Index (SCI) was developed that indicate to what degree a product or process concept can be regarded as compliant with a sustainable solution, see section 3 for more details about SCI.

The set of criteria represents the prioritized sustainability aspects to be considered during product development for the particular company in question both as long-term targets and urgent requirements. In this way the sustainability boundaries are defined and it will cover the important sustainability aspects to be considered when developing and evaluating product and process concepts. The process for developing the criteria is generic but the criteria it-self is company specific and likely branch specific as they are based on the sustainability demands and trends of the specific branch. The criteria can possibly help to put sustainability indicators derived from other sources, e.g. Joung et al. (2013) and Lu et al. (2011) into context. That means when the strategic sustainability criteria and tactical sustainability guidelines for the company are developed, relevant indicators and metrics could be chosen or developed.



Decision aspects concerning product life cycle phases	**Sustainability aspects guided by Sustainability Principle 1 (SP1):** ***Nature is not subject to systematically increasing concentrations of substances from the Earth´s crust.***		
	Strategic sustainability criteria	**Information/details (to strategic criteria)**	**Tactical design guideline**
Raw materials: *materials and chemicals that are used for the product components and/or its production.*	**No risk-materials used according to raw material lists.**	*Avoid dependencies of materials that have a potential to be critical from a business-and sustainability risk perspective. Therefore choose materials with low potential risk for secured future availability. This is especially important when used in production for several years. See material criticality list.*	**Reduce (in %) risk materials for product components and/or its production.**
	Strategic sustainability criteria	**Information/details (to strategic criteria)**	**Tactical design guideline**
Production: *production by suppliers of sub-components & materials, as well as production of products at the own company.*	**Only recycled materials are used, with no metal emissions and all scrap metals are recycled into pure fractions.**	*Avoid raw metals in product and production. This is especially important for critical materials. See material criticality list.*	**Reduce (in %) emissions and scrap of metals (especially containing critical materials).**
	Only renewable energy sources are used in the production processes to become a CO2-neutral facility and the energy usage in the production processes are efficiently used.	*Use an energy plan to identify potential for higher energy efficiency. Develop and implement an action programme and set targets for energy usage reduction.*	**Reduce (in %) fossil based CO2- emissions in the production processes.**

Figure 1. Excerpt of a sustainability criteria matrix. Separating the criteria into product life cycle phases and overarching socio-ecological sustainability principles.

1.2 Research approach

This work is part of a research process to give answers to the research question: *"How to define and develop sustainability criteria for use in early product development?"* This includes stages of descriptive and prescriptive research, using Maxwell's (2005) guidance for conductive qualitative research and the Design Research Methodology (DRM) presented by Blessing and Chakrabarti (2009). From the first research stage, which was an exploratory and descriptive study, (Hallstedt et al., 2013), eight key elements to successfully implement a strategic sustainability perspective were identified. The results from this descriptive study also formulated some guidance for sustainability criteria development that was used to build the suggested prescriptive approach for defining strategic sustainability criteria. This and coming research are part of the *third research stage,* which is a final descriptive study for comparison with the initial description and for making an evaluation of the impact of the prescribed changes.

Action Research (Avison et al., 1999) was conducted, which meant several interactive activities involving the researcher and practitioners at a case company during a period of several years. The case company was an engine component manufacturer in the aerospace industry and was selected as the research and development department wanted to increase the capability to integrate a sustainability perspective in their decision-making system. Further on it was expected that the engineers and designers in future would be faced with the problem to explore sustainability-related issues to identify business opportunities for technologies in new applications. The company therefore identified the need for suitable support tools in their decision-making system.

2 SUSTAINABILITY DESIGN SPACE

The purpose of defining a set of sustainability criteria for a company is to increase the ability to target the most relevant socio-ecological sustainability aspects in the early product innovation phases. Thereby also support mainly product developers or design teams in the development, evaluation and selection of concepts (products or processes) during the early product development phases. In this way, the knowledge of the design space with respect to sustainability in the early design phases will be increased, while the design freedom is still large (Ullman, 1997).

When sustainability-related criteria exist in product requirements today, they are often developed based on identifying things that are assumed to be desirable or not, along with being easy to assess. An example: minimization of energy is nearly always mentioned in regard to the sustainability of products, see e.g. Herva et al. (2011). To generally minimize the energy use is good; however, there are forms of energy that can be utilized with no or very low sustainability-related impacts: passive solar energy, for example. This to say: it is not energy minimization per se that is the goal, but rather the minimization of certain types of energy that are associated with negative sustainability impacts. This approach to sustainability, which is used in this paper, is essentially the same as the first element (definition of feasible regions) of the first principle (mapping the design space) of Set-Based Concurrent Engineering (SBCE) set out by Sobek et al. (1999). This means that the identified sustainability criteria define the sustainability design space for the product life cycle. These criteria should be used to set targets, and guide the development of concepts and new innovations at the company. To use a similar approach as SBCE gives a better understanding to the engineers and product developers, as it is a familiar way of thinking in the engineering environment.

2.1 Set of sustainability principles as constraints

By utilizing a set of sustainability principles as constraints that match with the early steps in set-based concurrent engineering a manageable and applicable list of criteria and design guidelines, see Figure 1, with the aim of balancing comprehensiveness (i.e. not being unnecessarily simplified in a reductionist way) with the ease of use was developed.

Sustainability is, in this sense, about contributing to a socio-ecological sustainable society. To define socio-ecological sustainability, the basic principles for global socio-ecological sustainability put forth by (Robèrt et al., 2002) are used in this paper. These principles were derived at by first assuming to arrive at a complete enough understanding of the global socio-ecological system so as to be able to define success for planning efforts within that system, i.e. a sustained human society, including the ecological system upon which society depends. This definition of success is delivered in the form of first-order principles that are applicable to any planning effort to arrive at the definition of success by virtue of being sufficient, necessary, concrete, generic, and non-overlapping. These principles are part of a framework for strategic sustainable development (FSSD), which has been developed, scrutinized, tested in reality, refined and scrutinized again in a 20+ years peer-reviewed scientific consensus process (e.g. Broman et al., 2000; Holmberg and Robert, 2000; Ny et al., 2006). The sustainability principles state that in a sustainable society, nature is not subject to systematically increasing… (1)…concentrations of substances from the Earth´s crust, (2)…concentrations of substances produced by society, (3)…degradations by physical means, and, in that society, (4) people are not subject to conditions that systematically undermine their capacity to meet their needs. The fourth principle is currently under development to explore a subset of social sustainability principles that aim to be more operational and easy to monitor (Missimer, 2013).

The sustainability principles described above are designed for "backcasting" in contrast with "forecasting" (i.e. analyzing and projecting current or historical trends). In short, backcasting means imagining success in the future and then looking back to today to assess the present situation through the lens of this success definition and to explore ways to reach that success (Dreborg 1996; Vergragt and Quist 2011). Backcasting gives support in being strategic in the development towards sustainability (Gaziulusoy et al., 2013), in part because it enables moving in the right direction via "flexible platforms" in order not to move into "blind alleys" that might prevent continued progress (Ny et al., 2006). In this paper "strategic sustainability" is referred to as the combination of these ideas, i.e. backcasting from sustainability principles. These sustainability principles act as system boundaries for sustainable solutions; anything within the boundaries is in essence the set of "sustainable solutions". However, being fully compliant with all sustainability principles is a definite challenge for most modern products.

2.2 Strategic criteria and tactical design guidelines

The set of strategic criteria and tactical design guidelines represent the prioritized sustainability aspects to be considered during product development for the particular company in question both as long-term targets (criteria) and short-term (design guidelines). In this way the sustainability design space is defined, which covers the important sustainability aspects to be considered when developing and evaluating product and process concepts.

The process steps to develop the criteria, tactical design guidelines and sustainability compliance index are described on an overarching level below. Shortly the criteria development is conducted in three steps: a) collect existing sustainability-related requirements and tactical design guidelines for the particular company or industry branch; b) review all product life-cycle stages through sustainability principles; c) reduce and select the tactical guidelines using meta-criteria. The steps a) and b) can be conducted in parallel and independently of each other. The criteria that are derived from these two steps represent short-term and long-term criteria and will be synchronized together later, before step c).

2.2.1 Collect existing sustainability-related requirements and tactical design guidelines

This step is based on a forecasting approach with the purpose of identifying the company and branch specific sustainability requirements that are relevant as criteria today and in the near future. Acknowledging that there are already requirements and design guidelines in development processes that relate to sustainability, the purpose is to identify and collect these. These requirements and guidelines can come from a variety of sources, such as i) product requirements: sustainability-related requirements that already exist e.g. in technical specifications for a product or previous environmental assessments of related products; ii) company requirements and goals, e.g. corporate documents and environmental policies; iii) industry requirements and goals, e.g. in the aerospace industry, the Advisory Council for Aeronautics Research in Europe (ACARE) publishes targets for e.g. future CO_2 emissions; and iv) existing regulations at national and international levels, e.g. REACH.

2.2.2 Review all product life-cycle phases through sustainability principles

Since the guidelines in the first step typically come from a forecasting approach based on known current problems, this step introduces a backcasting approach with the purpose of defining strategic sustainability criteria. The strategic sustainability criteria are long-term goals that the company should strive to fulfil. These are based on decision aspects concerning activities in each life-cycle phase in relation to sustainability aspects that are guided by the sustainability principles. This step begins by mapping out in detail the main phases of a product life cycle and consider decision aspects for these life-cycle activities: material source (i.e. raw material consideration), production, distribution, use and maintenance, end of life. These life-cycle phases were chosen because they are generic to the industry and covers the main activities that have an impact on the sustainability consequences of a product.

2.2.3 Reduce and select the criteria and guidelines using meta-criteria

The goal of the last step is to derive a manageable and applicable list of criteria and design guidelines with the aim of balancing comprehensiveness (i.e. not being unnecessarily simplified in a reductionist way) with the ease of use.

A set of meta-criteria used, was established and adapted from Schmidt and Butt (2006); and Dreyer et al. (2010):

- Applicability: Guideline must be applicable to different concepts.
- Logic and simplicity: Guideline needs to include a design objective that has an unambiguous measurement rule and measurement unit.
- Feasibility / data availability: Guideline must draw on information that is possible to obtain.
- Clarity: Each design guideline has to include a design objective that has a measurable entity.
- Relevance: Guideline must represent aspects of the sustainability dimensions

These meta-criteria have equal importance and were used as they allow for a comprehensive socio-ecological sustainability perspective, while also ensuring that the criteria will be usable in the operational working environment.

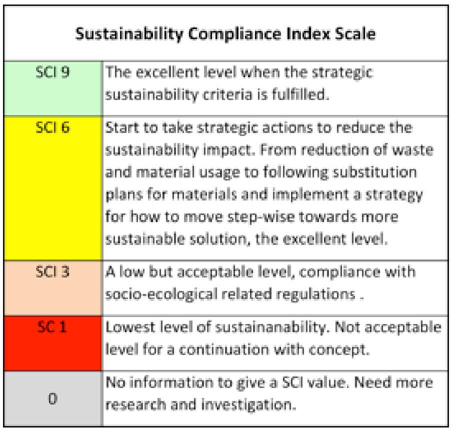
3 SUSTAINABILITY COMPLIANCE INDEX

The definitions of the criteria and index were according to below, and inspired from previous research (e.g. Renn et al. 2009 and Dreyer et al. 2010).

- *Strategic sustainability criterion:* is the ideal long-term sustainability target and something to strive for.

- *Tactical sustainability design guideline:* defines the prioritized sustainability aspect that supports a development towards the related long-term strategic sustainability criterion.
- *Sustainability Compliance Index (SCI):* levels of compliance for each of the strategic sustainability criteria.

The SCI matrix, was a high-resolution version of the overarching sustainability matrix (see Figure 1) for a deeper qualitative assessment containing levels of design guidelines. Each criterion in the overarching sustainability matrix is divided into four SCI levels. See Figure 2 for how the SCI-levels are defined. The development of the different levels was inspired by and adapted from other maturity or readiness scales such as Technology Readiness Level (Mankinds, 1995); Sustainability Integration Stages (Willard, 2005); Capability and Evolution Levels (Pigosso et al., 2013). The purpose of the SCI is to support a ranking of concepts and a comparison of different alternatives. It gives a qualitative assessment of a concept or a comparison of different concepts from a sustainability perspective. From the SCI levels, sustainability hotspots (SCI 1 or 3) of a studied concept can be identified and give guidance (SCI 6 or 9) to how to improve the socio-ecological sustainability profile of the concept. A SCI matrix can also be used to follow a development of a concept and visualize the progress towards a more sustainable solution.



Sustainability Compliance Index Scale	
SCI 9	The excellent level when the strategic sustainability criteria is fulfilled.
SCI 6	Start to take strategic actions to reduce the sustainability impact. From reduction of waste and material usage to following substitution plans for materials and implement a strategy for how to move step-wise towards more sustainable solution, the excellent level.
SCI 3	A low but acceptable level, compliance with socio-ecological related regulations .
SC 1	Lowest level of sustainanability. Not acceptable level for a continuation with concept.
0	No information to give a SCI value. Need more research and investigation.

Figure 2. Sustainability Compliance Index (SCI) scale.

4 VALIDATION OF CRITERIA AND THE SUSTAINABILITY COMPLIANCE INDEX FOR EVALUATING CONCEPTS

A set of first evaluation tests was conducted, with purpose to give a first indication and evaluation of the ability to give guidance and support in bringing in a sustainability perspective when developing, evaluating and selecting different concepts in the early phases of product development. More detailed and advanced testing, evaluation and validation is planned for in future research. These first pilot-tests, however, gave indications of the relevance of the sustainability criteria, guidelines and ideas for improvements.

4.1 Evaluation of the sustainability criteria

One workshop session was set up as part of the evaluation of the overall sustainability criteria matrix and the usability of the SCI. The purpose was also to get some ideas for integration possibilities in the company's decision support system. Reflections and feedback, triggered by some guided questions, were given from product development and design specialists (four employees) at the case company.

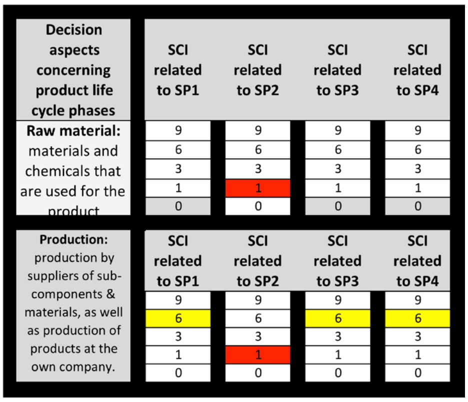
The result indicated the relevance of having some criteria linked to existing sources and material databases at the company. It was appealing to have short-term more urgent targets (design guidelines) that could act as flexible platforms to the long-term criteria. This was believed to give guidance when developing and selecting concept ideas, especially for concepts with a long life-time and long production periods. Further on the test group suggested the linking of the sustainability criteria and design guidelines to values and risks (e.g. innovation potentials, increased competitiveness, energizing employees, cost, profit, investments). Also, it was suggested to make the criteria measurable and comparable with typical design parameters (e.g. weight, dimensions, life length) for a multi-criteria concept selection process. All suggestions were listed for consideration in the next research stage.

4.2 Evaluation of sustainability compliance index

A pilot-test of the sustainability compliance index matrix was conducted on the case company´s production of a Low Pressure Turbine (LPT) case. The LPT case was assessed against the SCI with the purpose of evaluating the current sustainability profile and which issues to focus on in a future development. Data collection was performed through discussions with responsible persons from environmental specialist, production facility specialist, health and safety specialist and LPT specialist at the case company.

The two first life-cycle phases (raw material and production) were selected for evaluation and grading according to the SCI matrix developed for the case company. The result highlighted the areas that needed more research and investigation (marked as 0 or grey areas) and the areas that needed immediate improvements and actions (marked as 1). The current SCI-result for the LPT-case showed that sustainability relevant information is lacking and further investigation regarding raw materials is needed. For example, it was not known if any critical materials, i.e. alloys that have a future availability- and sustainability risk, were used for the LPT-case. See Figure 3 that presents a result from the evaluation of the current SCI for production of the LPT-case. (In Appendix A an excerpts of a more detail version of the result is presented). Further on information of the impact on the surrounding nature and evidence of acceptable working environment at sub-suppliers were not known. Therefore three out of four criteria were scored 0 for the current LPT-case. On the other hand the SCI-level regarding production was high. Three out of four criteria scored at level 6, which means that the company had taken strategic actions to prevent impacts already. At the same time one criteria regarding hazardous chemicals used in production was highlighted, as it did not reach an acceptable sustainability level. From the result of the current SCI-level for the LPT-case a road map with suggested SCI levels from 3 and higher for all criteria to be targeted in the future were presented to the company's management team. (For details see Strömberg and Thulasi (2014)).

Further testing of the SCI matrix is needed in order to validate the support in assessing and comparing different concepts. However, this pilot-test gave indications of valuable results that could be used to communicate and visualize the progress towards a more sustainable solution.



Decision aspects concerning product life cycle phases	**SCI related to SP1**	**SCI related to SP2**	**SCI related to SP3**	**SCI related to SP4**
Raw material: materials and chemicals that are used for the product	9	9	9	9
	6	6	6	6
	3	3	3	3
	1	🟥 1	1	1
	0	0	0	0
Production: production by suppliers of sub-components & materials, as well as production of products at the own company.	**SCI related to SP1**	**SCI related to SP2**	**SCI related to SP3**	**SCI related to SP4**
	9	9	9	9
	🟨 6	6	🟨 6	🟨 6
	3	3	3	3
	1	🟥 1	1	1
	0	0	0	0

Figure 3. Result of the SCI for the LPT-case.

5 CONCLUDING DISCUSSIONS

The aim of this research is to present an approach to define detailed concrete sustainability criteria and a SCI to be able to measure and to set sustainability targets in product design. The defined sustainability criteria represent the sustainability design space and will be used together with the other domains of requirements and restraints. The sustainability design space may aid by i) illuminating previously unexplored design space, and/or ii) further constraining the applicable design space to reduce the space that needs to be explored.

It is likely that the preferred, or even allowable, design spaces are not compliant so the designer's first task is to carefully understand the limitations and restraints of the given design pre-conditions. The designer can use the design space mapping as a way to understand limitations and opportunities before actually identifying plausible concepts. Questions guiding the forthcoming design work can be formulated as "What would be necessary to merge these design domains even more?" "What would be the consequence of violating one, or several, design domains?" "Can we modify the restraints and assumptions for the design domains to become more sustainable compliant?" The introduced Sustainability Compliance Index (SCI) can be used to give guidance on the current level of design space and how to improve the socio-ecological sustainability profile of the concept to reach the highest level (level 9) on the SCI scale (complete alignment).

The result from company feedback and early pilot-testing concluded that the sustainability criteria can give guidance in the pre-design phase when developing and selecting new concepts; and, the sustainability compliance index can give support in doing a qualitative assessment of a concept (product or process) or a comparison of different concepts from a sustainability perspective. The case study and pilot-tests also indicated that there is a need for further development and validation, for example, to link the sustainability criteria and design guidelines to values and risks (e.g. innovation potentials, increased competitiveness, energizing employees, cost, profit, investments), as well as to make the criteria measurable and comparable with typical design parameters (e.g. weight, dimensions, life length) for a multi-criteria concept selection process. Previous and current work such as Vogtländer et al. (2001 and Bertoni et al. (2014) can be used as inspiration or base for how to connect sustainability criteria with value-models and how to translate sustainability consequences in monetary terms. The economic dimension, normally described as one of the three pillars in the triple bottom line approach, is here considered as part of the value- and risk perspective and will be further explored and investigated in regard to how it relates to the sustainability criteria matrix in future research.

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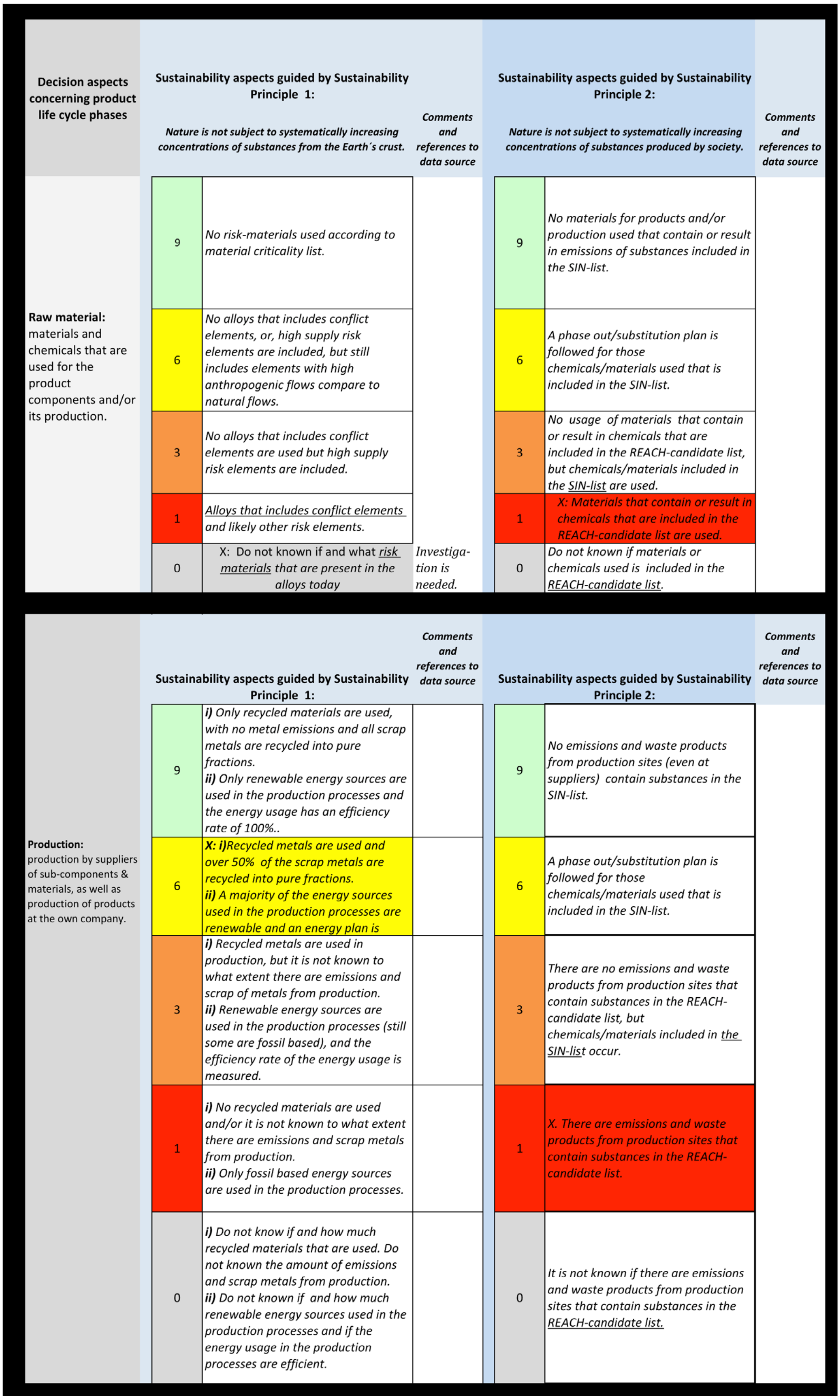
APPENDIX A: EXCERPTS OF THE RESULT OF THE SCI MATRIX OF THE LPT-CASE



Decision aspects concerning product life cycle phases		Sustainability aspects guided by Sustainability Principle 1: *Nature is not subject to systematically increasing concentrations of substances from the Earth´s crust.*	*Comments and references to data source*		Sustainability aspects guided by Sustainability Principle 2: *Nature is not subject to systematically increasing concentrations of substances produced by society.*	*Comments and references to data source*
Raw material: materials and chemicals that are used for the product components and/or its production.	9	*No risk-materials used according to material criticality list.*		9	*No materials for products and/or production used that contain or result in emissions of substances included in the SIN-list.*	
	6	*No alloys that includes conflict elements, or, high supply risk elements are included, but still includes elements with high anthropogenic flows compare to natural flows.*		6	*A phase out/substitution plan is followed for those chemicals/materials used that is included in the SIN-list.*	
	3	*No alloys that includes conflict elements are used but high supply risk elements are included.*		3	*No usage of materials that contain or result in chemicals that are included in the REACH-candidate list, but chemicals/materials included in the SIN-list are used.*	
	1	*Alloys that includes conflict elements and likely other risk elements.*		1	*X: Materials that contain or result in chemicals that are included in the REACH-candidate list are used.*	
	0	X: Do not known if and what *risk materials* that are present in the alloys today	*Investiga-tion is needed.*	0	*Do not known if materials or chemicals used is included in the REACH-candidate list.*	

Decision aspects concerning product life cycle phases		Sustainability aspects guided by Sustainability Principle 1:	*Comments and references to data source*		Sustainability aspects guided by Sustainability Principle 2:	*Comments and references to data source*
Production: production by suppliers of sub-components & materials, as well as production of products at the own company.	9	***i)*** *Only recycled materials are used, with no metal emissions and all scrap metals are recycled into pure fractions.* ***ii)*** *Only renewable energy sources are used in the production processes and the energy usage has an efficiency rate of 100%..*		9	*No emissions and waste products from production sites (even at suppliers) contain substances in the SIN-list.*	
	6	***X: i)****Recycled metals are used and over 50% of the scrap metals are recycled into pure fractions.* ***ii)*** *A majority of the energy sources used in the production processes are renewable and an energy plan is*		6	*A phase out/substitution plan is followed for those chemicals/materials used that is included in the SIN-list.*	
	3	***i)*** *Recycled metals are used in production, but it is not known to what extent there are emissions and scrap of metals from production.* ***ii)*** *Renewable energy sources are used in the production processes (still some are fossil based), and the efficiency rate of the energy usage is measured.*		3	*There are no emissions and waste products from production sites that contain substances in the REACH-candidate list, but chemicals/materials included in the SIN-list occur.*	
	1	***i)*** *No recycled materials are used and/or it is not known to what extent there are emissions and scrap metals from production.* ***ii)*** *Only fossil based energy sources are used in the production processes.*		1	*X. There are emissions and waste products from production sites that contain substances in the REACH-candidate list.*	
	0	***i)*** *Do not know if and how much recycled materials that are used. Do not known the amount of emissions and scrap metals from production.* ***ii)*** *Do not known if and how much renewable energy sources used in the production processes and if the energy usage in the production processes are efficient.*		0	*It is not known if there are emissions and waste products from production sites that contain substances in the REACH-candidate list.*	