Whitepaper

Integrating ecodesign into product development

A step-by-step guide on how to approach the integration of sustainability indicators into company-specific development processes.

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Inhalt

1 Preface

Our economic systems are largely based on innovation and the urge to improve our standard of living [1]. Advancing technological knowledge has been identified as one of the most important factors of economic growth in the last decades [2].

> *"Growth […] is driven by technological change […]."* [1]

While this is largely embedded in our society, the environmental impacts of our system cause serious concerns about future well-being [3]. In recent years, the development of new or improved products thus often faces the challenge of creating an equal or better service with reduced environmental impacts [4]. While being a challenge in itself, innovation also is necessary to make products more sustainable. Numerous companies thus strive to reduce the impact of their actions to a healthy minimum by integrating sustainability concerns into their development processes.

> *"Enhancing technology innovation systems can provide opportunities to lower emissions growth […]."* [3]

Since the inclusion of sustainability concerns into product development is not an easy task, research is needed to work on standardised processes and more efficient incorporation of sustainability metrics [5]. The guideline presented in this document aims at providing the reader with a practical guide on how to integrate sustainability metrics into product development. The work conducted for the guideline was part of a project funded by the Ministry of Economy, Labor, and Tourism in Baden-Württemberg, Germany. A project description can be found under [6]. The participating institutions are namely:

University of Stuttgart, Institute for Acoustics and Building Physics (IABP)

University of Stuttgart
Institute for Acoustics and Building Physics

Fraunhofer Institute for Building Physics IBP

Fraunhofer
IBP

Festool GmbH

FESTOOL

Instagrid GmbH

Instagrid

2 The industry’s motivation and path so far

The products we use and consume have significant impact on the environment [4]. To measure and minimise these impacts, the provision of environmental performance metrics becomes increasingly important for producing companies. Among other requirements, the European Union set out the Ecodesign for Sustainable Products Regulation (ESPR) in 2024 [4]. The directive sets ambitious targets for product sustainability, defines ways on how to track them (e.g. digital product passports, DPP) and establishes sanctions for products not complying with the directive.

Producing companies in Europe are especially committed to reducing the impacts of their products throughout the entire lifecycle. Efforts are being made in various fields to reduce the impacts of products. Some activities focus on prolonged lifetime and durability of goods in order to prevent overproduction and overconsumption. Others target cleaner production practices and the use of renewable energy sources, sourcing from consciously acting suppliers, a large depth of production to have full control over processes, the work in strategic consortiums and supporting in defining industry standards or setting strict and specific reduction goals.

„The development of sustainable products requires consideration of a wide range of information. Their nature and scope depends on the respective sustainability indicators “

- Moriz Schmidt @ Festool GmbH **-**

Despite large efforts being made in these areas, more than 80 % of the environmental impact of a product is determined during the design stage [7]. Thus, improving products regarding their environmental performance is a main focus area for companies with design sovereignty. Yet, this is not an easy task. In order to improve a product in terms of environmental performance, respective indicators must be available. However, information on the product under design evolves continuously throughout the development process and relevant information is often not available until key decisions are made. Moreover, it has been known for some time that the environmental impact of a product is largely defined along other product characteristics during the design stage [8]. Yet integrating sustainability assessments into early product development phases is essential to actually change the design of products. This difficulty is commonly known as the “ecodesign dilemma” or “environmentally-conscious design paradox”(Figure 1) [9].

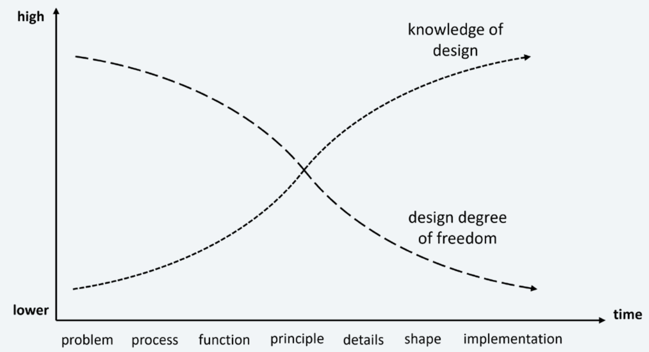


Figure 1: Environmentally conscious design paradox [9]

Product development usually is standardised and streamlined within companies. Overarching frameworks, such as VDI/VDE standards 2221 and 2206 [10, 11] strive to formalise the product development process on a general level, yet their interpretation varies largely across companies. In addition, product development usually is a process in which high efficiency is extremely important. The consideration of environmental impacts of products currently creates additional workload and falls under the risk of being neglected in busy development phases. Company-specific ecodesign approaches are thus essential to ensure seamless integration of sustainability considerations.

The steps outlined by the VDI/VDE standards mentioned above also serve as a basis for the provided guide for the integration of ecodesign metrics into product development. Goal of this guide is to enable companies to establish ecodesign concepts specifically for their processes. Individual creation of the ecodesign concept is necessary due to a variety of reasons (e.g. different requirements for indicators or sustainability metrics, different development processes, different state of the art in assessments or differing data sources). Therefore, steps for incorporating sustainability metrics into product development processes are outlined in the following part of the report. Starting from potentially roughly defined company goals, sustainability requirements and measuring strategies are established. For those sustainability requirements, indicators are defined to verify that the requirements have been met. Data needs for the indicators and data availability along the development process are matched and a sustainability integrated development process is developed. In a last step, the ecodesign concept is validated and tested

3 Six steps towards an ecodesign concept

In the following, steps for developing ecodesign concepts specifically towards the needs of companies are outlined. The goal of the procedure is to incorporate the assessment of sustainability indicators into the product development process. Developers must be provided with the necessary information for reasoned decisions as early as possible for them to make an impact. The steps below shall be seen as an iterative process with steps being repeated and returned to as often as required. Figure 2 summarises the key activities and questions visually.

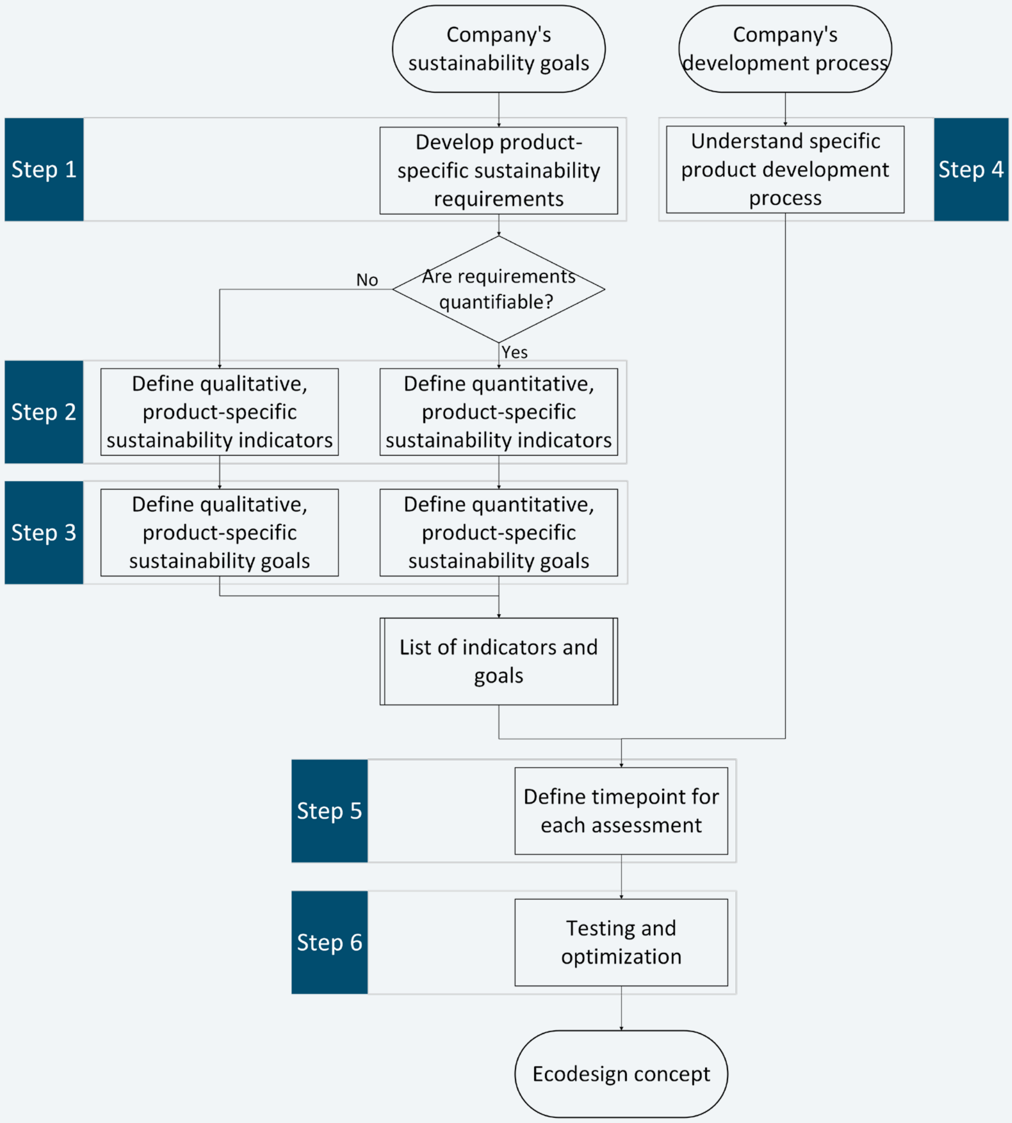


Figure 2: The steps towards company-specific ecodesign concepts

Step 1: Develop product-specific sustainability requirements

Goal: Establish a list of product-specific sustainability requirements that are formulated as precise as possible.

The first step of developing ecodesign concepts is to sort out sustainability requirements within the company. Abstract or specific company-wide goals shall be translated into product-specific requirements. This is not always an easy task, since some goals will be easier to break down to product level than others. Also, the assessment of company-wide goals might have a completely different scope than product-related impacts (e.g., the inclusion/ exclusion of personal travel). In general, the higher the level of company goals is, the easier they can be transferred to product goals. On the other hand, the more general a company-wide goal is, the harder it is to define specific requirements. If no company-specific goals are in place, legislative requirements can be used as minimum requirements. In other cases, product-specific requirements will present the starting point, especially if products are specifically designed to exceed current practices (e.g. product lines with lower impact). Rough requirements on product level are then used to derive more specific requirements based on the product architecture and technical restrictions. For example, a plastic part comes with the requirement of a high circularity. The only viable circularity strategy identified for the part is recycling, thus the derived requirement is a high recyclability. This again limits the use of flame retardants as additives of the plastic compound. As there are significant overlaps, sustainability requirements should thus be treated the same way as technical requirements.

Guiding questions:

- Are company goals for sustainability in place?
- Can company goals be translated to product-specific goals?
- Can product-specific goals be translated to product-specific requirements?
- Are there product-specific requirements that are detached from company goals?

Step 2: Define product-specific sustainability indicators

Goal: Define indicators to make requirements measurable in the development process.

For each of the requirements defined in the first step, measuring methodologies must be identified. This has the goal of objectively testing the fulfilment of requirements and goals. Indicators should be selected with care as they majorly define the next steps in the development of ecodesign concepts. If possible, indicators shall be reused as often as possible across products to make comparisons possible and streamline the ecodesign process within a company. Indicators with broad application in the industry or the specific sector shall be prioritized. A helpful step in defining relevant indicators can be to establish obligatory (MUST) and optional (WANT) indicators. This prioritization of indicators must be in line with the requirements defined beforehand. Once a set of indicators is decided on, data needs for every single indicator must be understood and listed. It should be considered that some data will always be difficult to gather during product development stages (e.g. information on maintenance activities during the use phase) and data needs that can be satisfied by assumptions shall be identified. Other data sources that are not directly linked to the product development process (e.g. indicator ratings of previous product lines, externally provided indicators) should be identified to increase the efficiency. If there are data quality requirements in place, they should be elaborated and compared to expected data qualities along the product development process. The result of this step is a list of indicators that are targeted to integrate into the product development process. Data needs for the indicator calculation are clarified.

Guiding questions:

- Are there indicators that are externally required to provide?
- Which indicators represent the requirements and goals?
- What are specific data needs for the indicators?
- Which data needs can be satisfied by assumptions?
- Are the selected indicators realistic to calculate in the company?
- Are data quality requirements realistic to achieve in the product development process?

Industry insight

Festool is a manufacturer of high-quality power tools specialized in professional applications in woodworking and metalworking. The company is renowned for innovative products and a high quality of their tools.

In cooperation with the research partners, **Festool** has developed a list of sustainability Key Performance Indicators (KPIs). The list will help in future development processes in ensuring the development in accordance with external sustainability requirements and internal sustainability goals.

The following indicators were identified as central to sustainability within **Festool** and thus included in the sustainability KPI list:

- LCA-Indicators (standard indicators)
    - Climate change
    - Eutrophication
    - Acidification
- LCA-Indicators (additional indicators)
    - Land use
    - Biodiversity
    - Cumulated energy demand
- Circularity: Material Circularity Indicator (MCI)
- Life Cycle Costing (LCC) indicators (undiscounted costs)
- Costs from CO_2 taxes
- Lifetime and power input & output during use

Required data for each indicator was assessed and compared to the data available throughout the product development process. This information was used to time indicator assessment.

Step 3: Define indicator goals

Goal: Quantitative and qualitative goals are set for each indicator.

This step aims to combine the information obtained from the two previous steps. The indicators act as validators of the requirements and/or goals in the form of test cases. Two approaches of dealing with indicator goals are possible: The first way considers qualitative goals for each indicator. A qualitative goal could be "An assessment for indicator X is performed and used as a basis for decision in material choice". While this approach of handling indicator goals consolidates the use of previously defined target indicators, the benefit is limited.

To test goal achievement more effectively, quantified goals can be set. This provides the advantage that product developers become more committed to optimising the product towards sustainable performance metrics. Just as for the step of requirements management, quantified company goals cannot always be easily transferred to products and a realistic goal definition is important. For example, a company's goal of reducing greenhouse gas (GHG) emissions by 30 % until 2030 does not directly translate to every product causing 30 % less GHG emissions compared to a previous product generation. Thus, realistic and manageable goals should be set at this stage of the ecodesign concept.

Guiding questions:

- Are goals per indicator quantifiable?
- What are quantitative goals for each indicator?
- Are there minimum requirements for certain indicators?

Step 4: Understand the specific product development process

Goal: Build a deep understanding of the product development process and the increasing data availability throughout.

Probably the most important step while creating ecodesign concepts is to understand the company-specific development processes. It is relevant to understand the procedure and especially the timing of the steps. A focus must be set on those steps that influence the product-related data availability. This should be done with the previously identified data needs for sustainability indicators listed. Especially those data points that cannot be substituted or complemented with secondary data must be filled before an assessment can take place. Identifying the earliest timepoint of availability within the product development process for these data points is thus a priority.

The result of analysing the development process should be a mapping of available data relevant for the targeted sustainability assessments within the development process. Figure 3 exemplifies the result of this step based on the generic product development process by Ulrich and Eppinger [12] and to be expected relevant data points.

Guiding questions:

- Which product characteristic is defined at which point?
- What are specific and existing relevant data sources (e.g. Product lifecycle management system, PLM)?
- Is there data that cannot be collected from existing systems within the company?
- When are these data sources available?
- Who is responsible for the most relevant steps (e.g. product owner)?
- Are there gates after which certain product characteristics cannot be changed anymore?

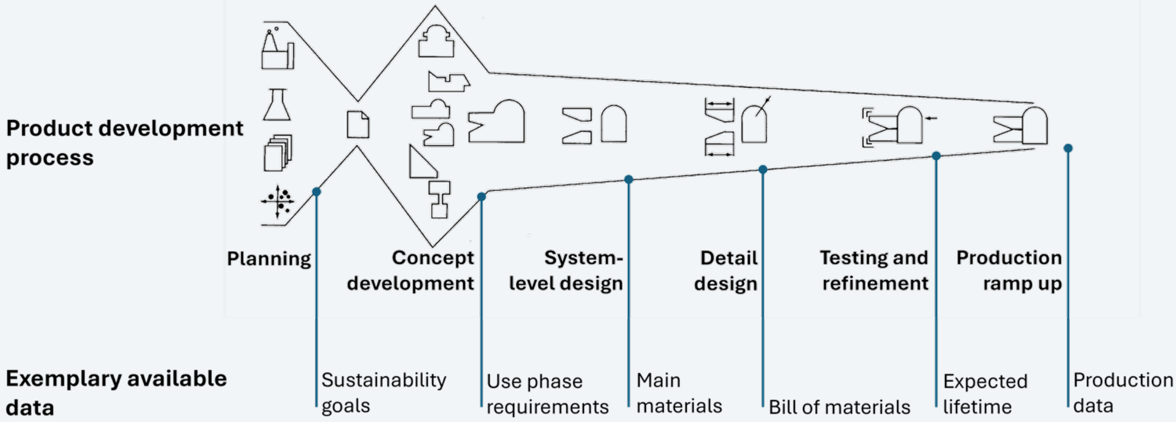


Figure 3: Generic product development process by [12] and expected available data

Step 5: Define timepoints in the product development process for each assessment

Goal: All indicators have a dedicated timepoint at which they shall be calculated.

This step of creating an ecodesign concept follows directly on from the previous one. After data availability along the development process is identified, it can be concluded at which timepoint all data essential for a certain indicator is available. This is the earliest timepoint the indicator can be assessed. If there are indicators for which data is generally available early in the development process but single datapoints are not available until late, substitutability (e.g. by assumptions or generic datasets) shall be checked again. Sometimes it also reasonable to split assessments into multiple stages, giving the developers first advice early on while providing results with higher reliability later in the process. This can, for example, take place based on life cycle stages, individual components, screening and full assessments or separate indicators for the same sustainability goal.

It should also be considered how long the assessment of an indicator takes within the product development process. If, for example, the bill of materials is available shortly prior to a major development gate and the targeted indicator assessment takes longer than the time available until the gate, results might come too late for changes in the product's design. If time efficiency is identified as a concern in the development process, efficiency strategies, such as automation and standardisation, can help in shortening the indicator provision times.

To make the inclusion of sustainability indicators obligatory, their provision should be included as fulfilment criteria for major development gates. This prevents a progressing development process from relying on indicators that cannot keep up and lag behind, thereby minimising their impact.

The overall objective of ecodesign concepts of this kind is to continuously guide development by providing indicators as early as possible. Therefore, the goal of this step is to create a temporal mapping of indicators in the development process as the main process for ecodesign. An early inclusion of indicators is a high priority and measures for providing them in time for major design decisions should be discussed. Figure 4 shows an example of this tiered approach based on data availability for life cycle assessment (LCA) and the resulting possible indicators.

Guiding questions:

- At which timepoint is all necessary data for an indicator available?
- Are single datapoints too late for respective design decisions?
- Can late datapoints be substituted or complemented by secondary data?
- Does the duration of indicator assessment match the timeline of product development?
- Can indicator provision be included in gate fulfilment criteria?

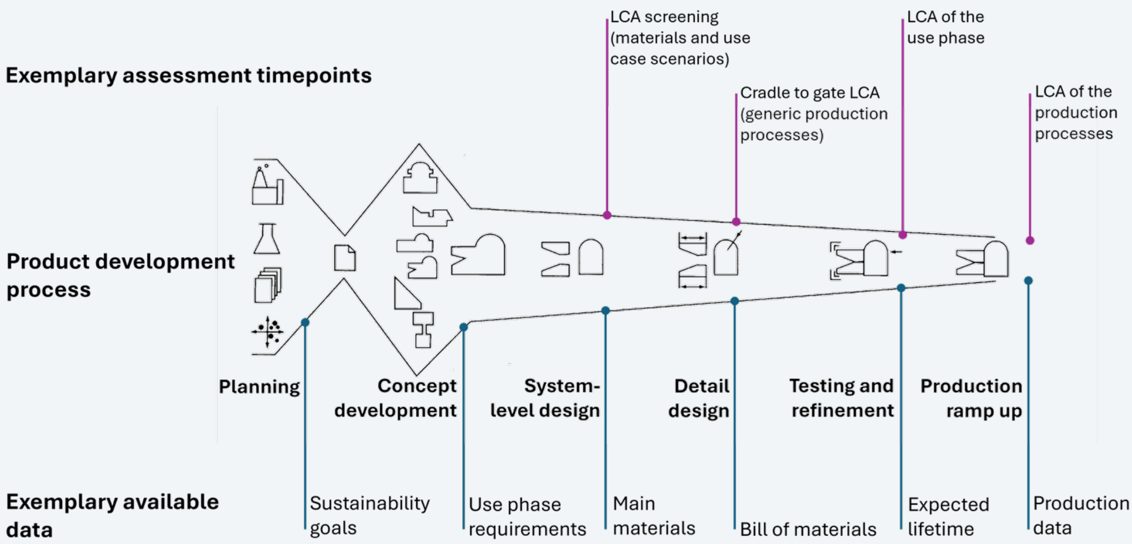


Figure 4: Generic product development process by [12], expected available data and exemplary sustainability indicator timing

Step 6: Testing and Optimisation

Goal: Validate the created concept and eliminate flaws.

The developed ecodesign concept must be thoroughly tested to verify and validate its operability. To do so, the calculation of every indicator for the defined timepoints in the product development process must be conducted. The availability of all datapoints at the defined timepoints shall also be tested. Data quality must be assessed and strategies for managing data quality should be elaborated. Time efficiency is to be investigated since the ecodesign process should not hold back the overall product development. Automation and other efficiency strategies can be explored if the speed of the sustainability assessments cannot hold up with the product development process. On a more general note, the integration of all indicators shall be questioned to whether the added knowledge in the product development process justifies the effort of integrating the indicators. For all indicators that rely on single, late datapoints, substitution by generic data or assumptions should be considered to move assessments to the earliest possible timepoint. Wherever necessary, the concept is to be adjusted as needed using the steps explained above in an iterative process.

Guiding questions:

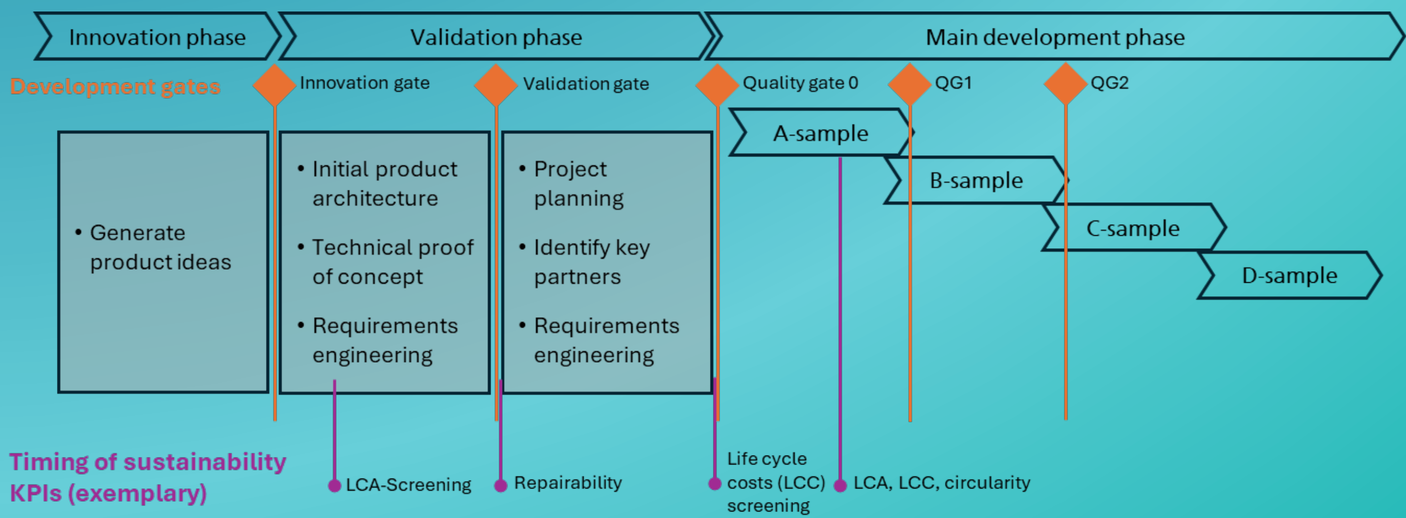
- Can the ecodesign concept be implemented as intended?
- Can all indicators be calculated at the defined timepoints?
- Does the ecodesign concept cause delays in the product development process?
- Is data quality sufficient?
- Does the integration of indicators benefit the achievement of the company's goals?

Industry insight

Instagrid is an innovative company that develops mobile power solutions to supply energy to construction sites and other workplaces independently of fixed power connections. Their products combine modern battery technology with user-friendly applications to ensure a flexible energy supply.

Together with **Instagrid**, the timing of indicator calculation throughout the product development process was tested. For this purpose, timepoints for the calculation of specific indicators were defined. The main goal was to include indicators as early as possible in order to drive the development towards more sustainable practices. The decision on timepoints was majorly based on data availability in the specific steps in the product creation process.

The calculation of some indicators could already be tested with data from ongoing product development processes. While challenging, the testing of the procedure provided valuable insights both into the process of ecodesign and the assessed product. The figure below resembles the development process at Instagrid. The timing of some of the selected sustainability indicators is highlighted.



4 Conclusion

The steps outlined above provide a practical approach for establishing company-specific ecodesign concepts. By integrating sustainability indicators into the product development process, requirement fulfilment can be tested and product-related issues can be addressed. The development of the procedure in a team of researchers and companies proved to be very successful and provided the participating companies with the relevant tools to implement ecodesign concepts.

In further research projects, the step-by-step guide will be refined and tested with more companies to improve it further. The specific procedure can vary for each company and more case studies will help in finding a suitable approach for many stakeholders. The guide above should therefore be seen as a starting point for individual, company-specific approaches.

„In a next step we will implement the specific ecodesign concept in our product creation process and evaluate the benefits. Our goal is to integrate sustainable thinking deep inside Instagrid's product creation to reach our ambitious sustainability goals. "

- Sam Yeboah @ Instagrid GmbH **-**

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