FROM THE CRADLE TO THE RESURRECTION

SUSTAINABILITY GOALS FOR THE PRODUCT LIFE CYCLE

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What actually makes a product "sustainable"? ROI-EFESO's "Product Life Cycle" approach classifies sustainability goals that can relate to physical products, software or services (see graphic page 22/23). The approach thus provides companies with a guidance framework to track these goals from the initial idea to recycling. Different focal points can be set in the four phases of the life cycle explained below.

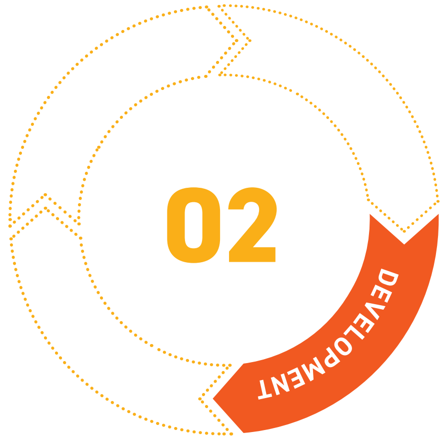
IDEA GENERATION

What options are there to make an existing product even better in terms of sustainability criteria? Or even to develop a completely new one that meets a customer need and at the same time has a perfect sustainability footprint? Pooling and focusing creativity and resources on sustainable product ideas is perhaps the greatest challenge of this phase.

SUSTAINABILITY AS A DRIVER FOR INNOVATION

The first step is to examine the methodological and organizational prerequisites in the company that enable sustainable product ideas to emerge. Specifications make sustainability tangible in goals, measures and limits, especially via the basic, performance and enthusiasm characteristics of the product. For example, performance and consumption are usually directly linked not only in cars, but also in other products such as household appliances or machinery. These product requirements set the framework for subsequent development, but also represent a kind of interface between the company and its customers. Both sides can be drivers of innovation here - Volvo's decision to limit the power of its vehicles to 180 kilometers per hour and to say goodbye to eight- and six-cylinder engines, for example, had a corresponding signal effect. Such decisions realign the product portfolio and at the same time cleverly address customer perceptions of the brand.

Higher costs for more environmentally friendly materials can be communicated as added value for the customer.



DEVELOPMENT

Of course, not every sustainable idea proves suitable for the development phase. With test runs, pilot projects or market research tools, companies find their own variation of a "filter" that identifies promising approaches for further development. Once this is done, the focus is on the following topics.

Specifications make sustainability tangible in goals, measures and boundaries.

EVALUATION OF THE ECO-INDUCED CUSTOMER EXPERIENCE

This is a crucial component of the customer benefit analysis, which simulates how the customer would experience the sustainability aspects themselves as well as the product as a whole. What changes, innovations and benefits are the focus here? Does the customer even notice the change? In this topic, the digital product dimension usually plays an important role. For example, anyone who can use an app to read how much electricity their photovoltaic system generates in real time and how much CO_2 it saves compared to other types of generation will experience this product completely differently than they would without such a tool.

DESIGN FOR SUSTAINABLE PRODUCT USE, MATERIAL COMPLIANCE

Is an e-vehicle model automatically "green"? Or does its production and scrapping create new environmental burdens? If you formulate the most concrete sustainability goals for your product at an early stage, you will be able to identify hurdles and risk zones more quickly. The principle of "sustainable design" is generally suitable as a guiding principle, which aims to transform the social, ecological and economic aspects of sustainability into a positive benefit for the environment, manufacturers and consumers. Closely related to this is an examination of the topic of material compliance (MC), i.e., compliance with laws and regulations that restrict or prohibit the use of certain substances and/or materials in products. This is usually expressed in the trade-off between the financial and environmental costs resulting from the composition of product components. Metrics can include the projected carbon footprint and other emissions or pollutants. At this point, one should also consider whether higher costs for more environmentally friendly components, for example, can be communicated and priced as added value for the customer.

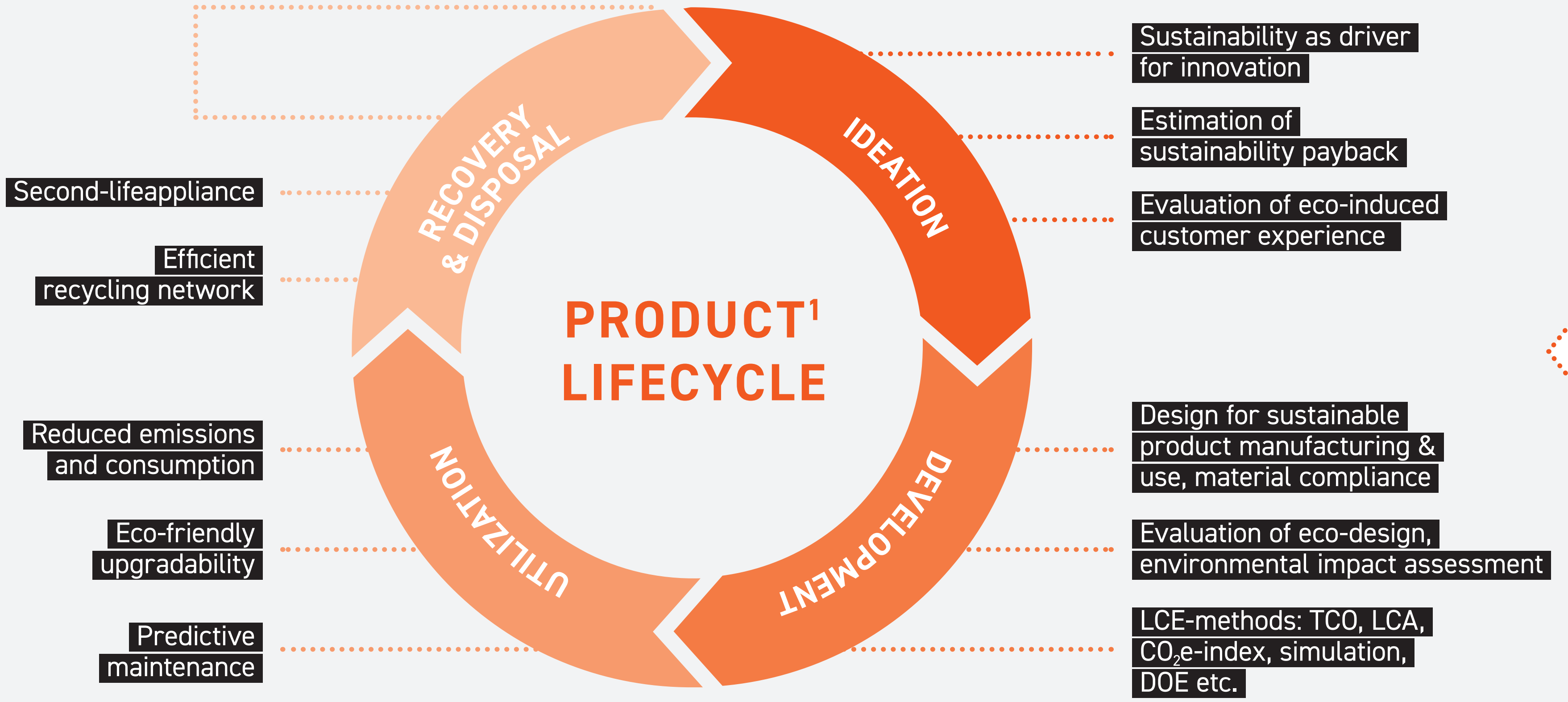
ESTIMATE AMORTIZATION OF SUSTAINABILITY

Another key element of this phase is the "sustainability payback," which is determined by looking at customer benefits and pricing sustainability functionalities and by modeling business models. This calculation is different for each product. However, a cost-plus calculation that focuses on material input and direct manufacturing costs as central benchmarks is not sufficient to solve this task. How much more would customers pay, for example, if a vehicle or machine had to be serviced at longer intervals and the period of use extended? After all, in order to offer such added value, higher-quality components must be used, which make the product more expensive. Methods such as conjoint analysis, the lead user concept or product clinics are helpful in this context.

ECODESIGN EVALUATION, ENVIRONMENTAL IMPACT ASSESSMENT.

To what extent is the product sustainable beyond manufacturing? The use phase of a product is particularly important and should be described or "simulated" as far as possible during product development. In the case of plastic injection molding machines, for example, the product and mold design determines the use of raw materials during operation. Electricity and water consumption as well as pollutant emissions during the use phase are indicators for a well thought-out and targeted sustainable product development.

PRODUCT DESIGN FOR SUSTAINABILITY



TARGETED DESIGN ACTIVITIES ENABLESUSTAINABLE PRODUCTS WITH THE FOLLOWING MASTERED COMPETENCES:

- *Balanced product-portfolio incl.sustainable products*
- *grated Life-Cycle-Engineering approachsupporting cycle-economy*
- *ted NPI / PDP anchoring sustainable approach in product design*
- *Implementation of sustainability management system for product ranges*
- *Reduced resource usage in product development (e.g., number of test samples)*
- *Use of digital potential for a global-consistent monitoring of the sustainability performance*
- *Anchoring of sustainability culture and mindset in product design*

[1] **Product** is everything that can be sold, e.g., a physical product, software and service
LCE: Life Cycle Engineering LCA: Life Cycle Assessment TCO: Total Cost of Ownership NPI: New Product Introduction
PDP: Product Development Process CO_2 e: CO_2 -Equivalent

LCE METHODS

Life Cycle Engineering (LCE) is an umbrella term that encompasses a range of methods used by companies to evaluate the aforementioned points. Life cycle assessment (LCA), for example, looks at the environmental impact of products throughout their entire life cycle. When applying these and other analytical methods, companies should create standards via processes and applications that address the broadest possible product spectrum within the company. This quickly reveals which competencies are missing, should be purchased or built up in-house.

These methods are ideal for creating an index for usage recording - i.e. for all environmental costs that do not result from production. In the case of a CO_2 -neutral injection molding machine, this can refer to its oil and electricity consumption during the complete use phase, among other things. And in the automotive industry, for example, we talk about the decarbonization index per vehicle, which is determined from the CO_2 emissions for a predefined usage behavior. This product view in turn gives rise to exciting new options. For example, how digital tools/functionalities can capture this information and make it measurable - and whether this data can also be used for purposes other than product improvement.

> *Modular upgrades are effective sustainability drivers.*

USAGE

The product and, if applicable, the services associated with it must then prove themselves in use. Those who have drawn the right conclusions from the analyses, tests and simulations of the preceding phases should now be in a position to offer their customers as well as the environment measurable advantages in the reduction of energy costs, emissions or pollutants. Three aspects are particularly important here.

PREDICTIVE MAINTENANCE

The classic use case for predictive maintenance is the upkeep of machines. Today, digital tools warn the operator at an early stage when a motor threatens to overheat or plant components show signs of wear. The principle of increasing the mileage or service life of the product, for example by sensors detecting wear and damage at more and more critical points, can be transferred to other areas of application and will continue to gain in importance in the future. This minimizes resources in the form of spare parts and protects the environment.

ENVIRONMENTALLY FRIENDLY UPGRADEABILITY

Does it have to be a new smartphone - or isn't it enough to replace the software or even individual hardware components if necessary? The failure of smartphone manufacturers who wanted to use a modular design to increase the product's longevity and reduce the resources required to manufacture it illustrates the dilemma behind this aspect. The approach of making the smartphone's processor and battery more durable, for example, makes ecological sense. However, it loses out to the economic factor as long as the customer does not buy the product.

In industry, modular upgrades are already effective sustainability drivers, for example in the case of machine tools or in special machine construction. Manufacturers of equipment for packaging production, for example, often already develop these for a higher output than is actually required in use. If the customer needs to increase output, the hardware and software can be retrofitted, i.e. configured, instead of having to install a completely new system. The customer saves money, the manufacturer can offer new services around this modular structure, and the ecological footprint of the product improves through longer use.

REDUCED EMISSIONS AND CONSUMPTION

The reduction of emissions and consumption is the core discipline - here, every new product generation should aim for zero values. The prerequisites for this are provided by the fields of action already mentioned. A good example is the battery of an electric car, whose maximum storage capacity decreases over the years. The storage locations of the latest battery generations are modularly structured in packages of cells that can be replaced individually. This means that the disposal or recycling of complete batteries will soon be a thing of the past. However, the example also illustrates that an overall lower resource consumption of the product often requires more development effort - these efforts, by the way, are strictly speaking also "consumption values". A high level of transparency is achieved by companies that include as many services as possible in their sustainability balance sheet as they pass through the product life cycle. In addition to the work required to develop special product properties, these are above all the manufacturing resources expended.

RECOVERY & DISPOSAL

The fourth phase involves the disposal or reuse of the product, either as a whole or in its component parts. Two challenges have to be solved here: What happens to materials/substances that cannot be reused? And more importantly, how can this phase already be taken into account in the other stages of the life cycle in such a way that the proportion of these materials is minimized?

EFFICIENT RECYCLING NETWORK

The use and disposal of product components such as batteries, plastics and lubricants can generate pollutants that cannot be easily disposed of. There are two options for reducing this proportion to zero or keeping it low: one is substitution, e.g. replacing plastic with another, ecologically degradable material; the other is the option of minimizing the use of the harmful materials. This requires a precise knowledge of what happens to the product during use and disposal, which in turn is an integral part of the development phase as "design for sustainable product use".

For example, some "green" products that include lithium-ion batteries pose a risk of flammability. Or toxic chemicals are used in the manufacturing process, e.g. to achieve higher energy storage efficiency. It is therefore the responsibility of product developers to minimize these proportions or to find new solutions - ideally in exchange with scientific institutions or research initiatives as well as the partners in the value network.

SECOND-LIFE APPLIANCE

A "second life" for the product is another ideal solution. This means that once the product has fulfilled its original purpose, it is simply reused in another area of application in order to minimize overall resource consumption. Examples include the use of rechargeable batteries from e-vehicles as a storage medium for real estate or the recycling of trains, through which individual components can still be used in other areas after many years without any problems.

Depending on the industry, there are still many options for improvement in this respect. In the case of household appliances, for example, a high proportion of large appliances are recycled, but reuse after repairs is still rare and not at all common in the case of smaller household appliances. However, improvements in the collection and sorting of small appliances in particular represent an important driver for higher recycling rates.

Every company that pursues a sustainability strategy should address the life cycle(s) of its products. Where to start in the sequence "from the cradle to the resurrection" is not necessarily decisive. It is more important to question successes anew: How can resource consumption be further reduced? How can the customer be inspired with a sustainable product design? This applies not only to the performance values of the end product, but also to resource consumption in terms of the materials used (and even in terms of the human capital employed) along all phases in the product life cycle. The more consistent the approach here, the better the balance sheet looks at the end of a long, green and profitable life cycle - and the more likely it is that the product or a high number of its components will be given a "second life".

> *Development resources are to be quantified as part of the product life cycle.*