SIEMENS

WHITEPAPER

Ecodesign: Scaling impact, shaping the world

How our design choices shape the world

Ecodesign, or the sustainable design of goods and services, aims to optimize and improve the environmental compatibility of technology. As such, it is an indispensable part of our efforts to protect the climate while making better use of finite resources and preserving biodiversity for future generations. Siemens applies the Robust Eco Design approach, which specifies the requirements for applying and implementing these principles, as a basic building block of our corporate DNA.

The planetary crisis

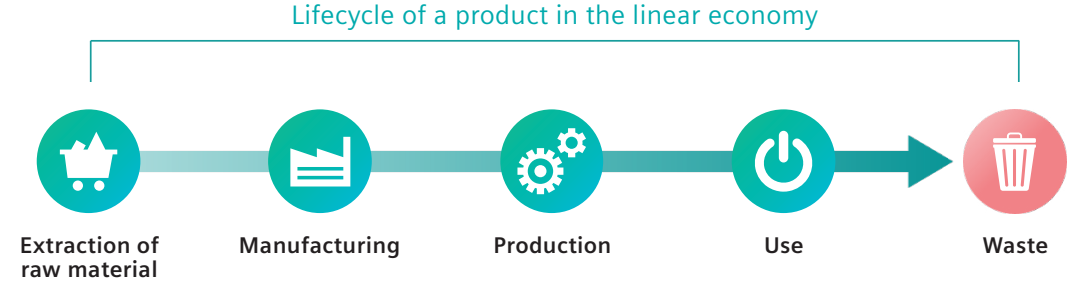
The term "Anthropocene" refers to the cataclysmic effect of humankind on the biological, geological, and chemical cycles of the current planetary era. Climate change and the loss of biodiversity are currently the main threats both to the stability and safety of global society and to the health and well-being of every individual. The ten warmest years since measurements began have all been recorded in the past two decades.

According to the Intergovernmental Panel on Climate Change (IPCC), global warming must be limited to 1.5 degrees Celsius if an increase of climate threats and risks to the ecosystem and humans is to be avoided.[1] However, megatrends such as urbanization, consumerism driven by a growing middle class, and the increase of waste and landfill use due to linear value chains are causing the release of additional greenhouse gases. A continuation of the traditional growth model is anachronistic and irresponsible.

Dangers related to the loss of biodiversity – i.e., the loss of genetic diversity and the variety of species (animals and plants) and ecosystems – are comparable to the threat of climate change, not least because the two risks influence each other. The global loss of species and ecosystems has many causes, largely related to changes in land use, e.g., deforestation, extraction of raw materials, intensive monocultures, and urbanization. In turn, ecosystems that are more heterogeneous and biodiverse are also more stable in the face of environmental change and can contribute directly or indirectly to the supply of resources and the regulation of the climate.

Against this background, it is important to assess products and their environmental impacts using accounting methods based on transparent and comprehensive data. Based on such an assessment, environmental impacts can be addressed especially effectively and holistically already in the planning and design phase using Ecodesign principles.

Illustration 1
Linear Economy



1 Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the IPCC Sixth Assessment Report. The IPCC was initiated by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). The intergovernmental global climate panel serves as a consultative body with responsibility for climate change issues.

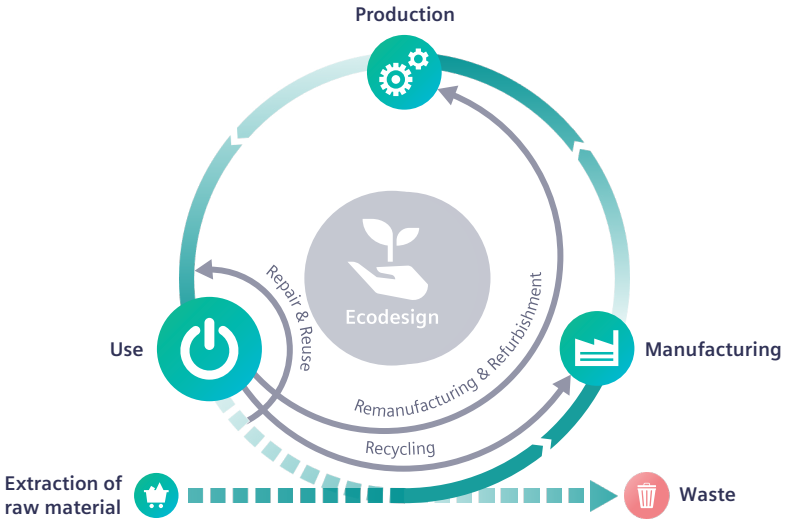


Illustration 2
Unlike the linear approach, Ecodesign enables a new, cyclical value creation

Ensuring environmental compatibility

Today, hardly any part of our planet remains untouched by human interference. Climate change and the loss of biodiversity threaten the resilience of the entire ecosystem. As planetary boundaries continue to be breached, critical tipping points are being triggered, setting in motion irreversible changes that will "tip" the climate system. Our ability to permanently (re-) shape and form the world harbors many risks, including the possibility that mankind might deprive itself of its own basis of existence. At Siemens, we are aware that product design has far-reaching effects on nature and our built environment. As a market leader and technology pioneer in many fields, we take a keen interest in minimizing these impacts throughout the lifecycle of our portfolio. Ensuring the environmental compatibility of our hardware, software, and services portfolio is a key priority. Collectively, the design principles that aim to realize this approach over the entire lifetime of a product are known as Ecodesign.

The concept of Robust Eco Design (RED) sets the framework for us to leverage our creative skills, our technical know-how, and our global presence in order to scale impact through environmentally compatible product design. Efficient and sustainable design of products also means shaping Planet Earth in such a way that it can continue to be a home and the basis of life for future generations.

The shift to a sustainable paradigm

The traditional growth model is based on the extraction of finite resources, processing them into products – mainly for single use –, and disposing of them at the end of their lifecycle ("take-make-waste"). Apart from certain recycling measures, this means that many finite resources are no longer available for further use.
Our goal is to implement a circular approach and to decouple economic development from resource consumption.

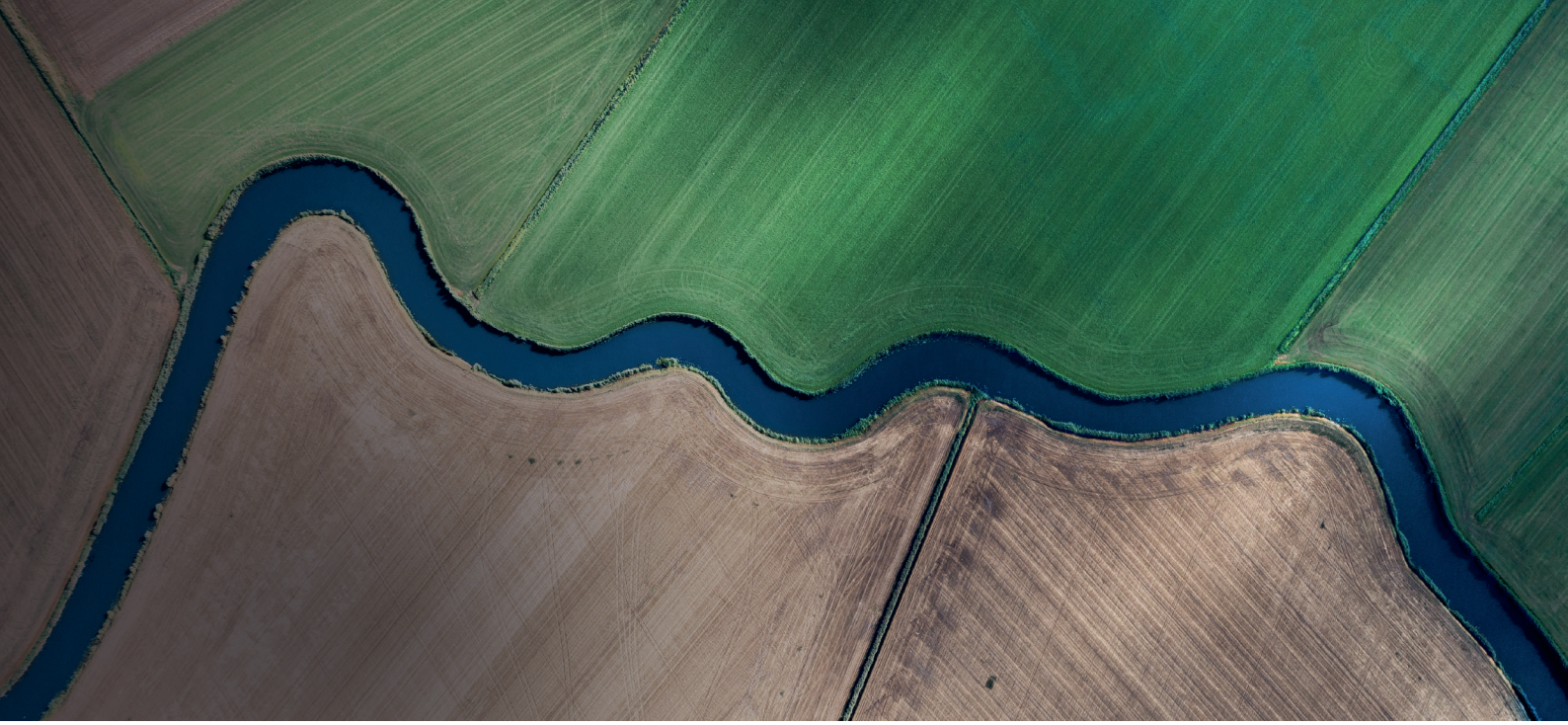
In the face of the global challenges at hand, many actors, ranging from societal stakeholders to supranational decisionmakers, have enacted sustainability policy measures to mitigate climate change and protect the biosphere while preserving prosperity, security, and health. These measures require significantly greater social and ecological diligence across the entire product value chain. The UN Sustainable Development Goals indicate some of the ways in which this can be achieved. Their comprehensive approach includes an acceleration of the Circular Economy, the energy transition, agricultural reform, and other targets that guide economies and societies toward more sustainable growth and prosperity.

What is Ecodesign?

The concept of Ecodesign is aimed at ensuring the environmental compatibility of products. It centers on reducing material consumption across the entire lifecycle while maximizing the use and value of all components and materials at all times. In this way, it aims to decouple economic activity from the release of climate-damaging gases and substances into the environment and from the use of finite resources.

Ecodesign aims to consider relevant ecological factors already during the planning and design of products, since this phase dictates up to 80 percent of their lifecycle environmental impact,[2] and to develop and conceive components and parts in such a way that they do not become waste. All design options are evaluated in advance to enhance the sustainability of products and associated processes along their entire value chains: from resource procurement, the production of precursor and final products, and (multiple)

2 Ecodesign your future – How ecodesign can help the environment by making products smarter. Publications Office of the European Union.

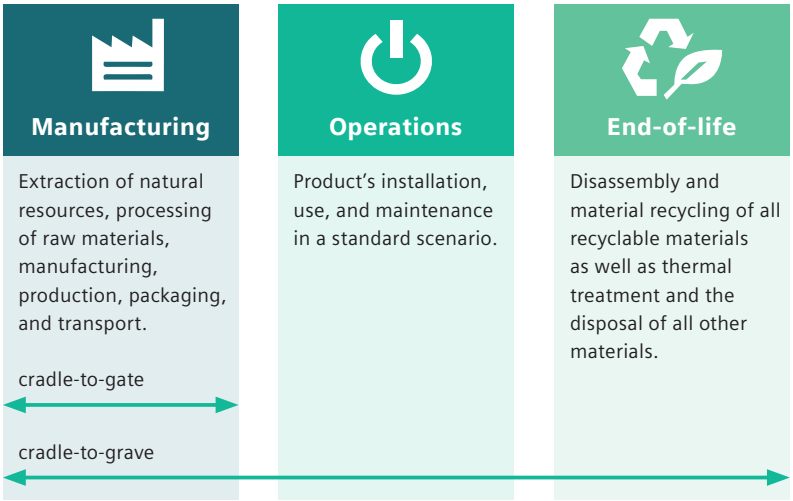


product use all the way to the end-of-life phase, including all logistics and transportation processes.

Avoiding waste, preserving resources

Ecodesign is an anchor of the Circular Economy, where resources are processed in a loop without creating waste and sustainable development is fostered by preserving, enhancing, or restoring the value of materials. Today, merely 7.2 percent of materials are preserved for further use,[3] while the rest is sent to waste disposal or incineration. This underscores the importance of assessing products using accounting methods based on transparent and comprehensive data and addressing their negative environmental impacts effectively and holistically already in the planning and design phase.

Illustration 3
Different scopes to account for lifecycle stages



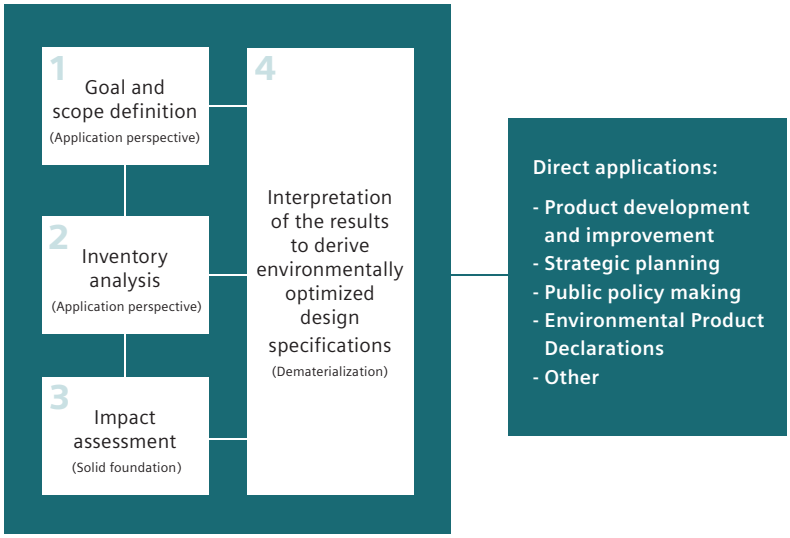
Such reporting is based on Environmental, Social, and Governance (ESG) criteria that deliver transparency for market participants and stakeholders. They facilitate decision-making based on the way in which investments and companies can improve their impact on climate change, water and land use, biodiversity, the release of substances, and the Circular Economy. We must ensure that corporate activities are in line with the Paris Agreement's ambition to limit global warming to 1.5 degrees Celsius and shape processes and portfolios in such a way as to preserve the natural basis of existence.

Sustainable business operations: Efficiency gains at all levels

Our strategic framework for Decarbonization, Ethics, Governance, Resource Efficiency, Equity, and Employability **DEGREE** allows us to determine and to manage the impacts of products on the environmental sectors of water, air, and soil by maximizing efficiency, i.e., achieving the same or higher benefit with less energy and lower resource consumption; minimizing the dissemination of non-natural substances into the environment; and managing the required technical and biological resources in a circular loop. This framework allows us and our customers to achieve efficiency gains by optimizing our own processes. It assigns an important role to collaboration in the value chain by facilitating services such as predictive maintenance, repairs and servicing, reuse and recycling, and collection systems. More sustainable business operations not only benefit the environment and

3 Circle Economy, The **Circularity Gap Report 2024**.

Illustration 4
Siemens RED phases support the four stages of an LCA according to the ISO norm



society at large, but also create opportunities for entirely new business and service models.

At Siemens, we operationalize three key categories within the Eco Efficiency program module: Responsible Product Development, where relevant portfolio elements are evaluated and subjected to Ecodesign criteria; the establishment of a Clean Supply Chain, decoupled from natural resource use by sourcing more secondary materials and significantly less declarable substances; and Efficient Own Operations, where we ensure efficient management of production sites and offices with improved waste management practices and effective use of clean energy.

Reproducible impact assessments

Such new business cases, revenue streams, and opportunities for optimization require that the environmental and climate effects of products and services – including, but not limited to their carbon footprint – must be quantifiable and traceable according to common global standards. This is done by performing a **Life Cycle Assessment (LCA)** that evaluates the ecological impacts of goods and services, either during selected phases or all phases of their lifecycle, ranging from resource extraction, manufacturing, distribution, and use stages to waste management, disposal, or transition to further use.

The LCA essentially involves four steps. First, the goal and scope of the analysis are defined, including whether to assess the environmental impact across all phases ("cradle-to-grave") or for individual lifecycle phases (e.g., "cradle-to-gate", from resource extraction until leaving the production site). In the next phase, data is gathered on all required incoming (energy, resources/materials) and outgoing (emissions, waste) flows of materials and energy and compiled into a Lifecycle Inventory. On this basis, all potential environmental and climate impacts and effects on human health or availability of resources are calculated and compiled in a Lifecycle Impact Assessment. This evaluation serves as a decision-making basis for successful Ecodesign and continuous improvement of environmental management.

The LCA can be used for benchmarking purposes or communicated via Environmental Product Declarations (EPD). Such a declaration facilitates correct balancing and can subsequently serve as a basis for product optimization. It enables further optimization of resource usage and supports the continuous elimination of pollutants as well as an improved environmental and climate balance sheet as intended by the Ecodesign concept.

The economic added value of Ecodesign

As noted above, the use of Ecodesign at all stages of the product lifecycle makes sense not only from an ecological perspective. Circular production and consumption models that envisage shared use, leasing, service and maintenance, repair, reuse, refurbishment, remanufacturing or recycling of existing materials and products for as long as possible and in continuous cycles also offer added economic value.

Ecodesign can improve the competitiveness of companies like Siemens, as well as of our customers, by reducing procurement costs for input materials and energy supply and by reducing waste volumes. At the same time, it strengthens the positions of all market players by enhancing their resilience to price volatility, shortages, and disrupted supply chains while bolstering their security of supply of raw materials. By adhering to Ecodesign principles, further cost benefits can be derived from innovative business models and production processes, extended lifetime for products, optimization of product use, or development of a well-functioning market for secondary resources, including through cross-industry collaboration. With our digital portfolio that enables the urgently needed switch to ecologically sustainable practices, Siemens

provides the technology backbone for sustainable growth.

Robust Eco Design: A future-oriented, resilient approach

Sustainability is part of the Siemens corporate DNA. It is not optional, but a must. Across its businesses and support functions, Siemens meets this challenge, including by implementing RED criteria for the relevant hardware, software, and services portfolio. Starting in 2021, we began implementing Robust Eco Design primarily across our hardware products, establishing a strong foundation. In 2024, we expanded our efforts to include software and services, strengthening our commitment to reducing the footprint of our offerings.

The RED approach provides the foundation for integrating Ecodesign systematically into our product development and allows us to derive Ecodesign specifications that are advantageous from an environmental point of view while meeting our own sustainability goals as well as those of our customers and suppliers. These goals are integral parts of our business that are not only expressed in numbers, but also reflected in the various aspects of the Siemens DEGREE sustainability framework (see above p. 4).

Application perspective

Determination of relevant portfolio, identification, and prioritization of Ecodesign requirements from stakeholder expectations

Solid foundation

LCA-based assessment of environmental impacts for representative products along the entire lifecycle, communicated via EPD

Dematerialization

Evaluation of quantitative environmental impacts of Ecodesign and of further requirements, derivation of improved design specifications wherever reasonable

RED phases for future-fit product families
RED serves the vision of an eco-compatible hardware, software and services portfolio, and is centered on the systematic application of Ecodesign to all relevant lifecycle phases. The aim is to make the product life as environmentally compatible as possible from the earliest possible stage and to recycle all materials while minimizing material and energy flows and losses. The RED approach involves three phases. The first is based on the **application perspective,** where the goal and scope of requirements for our relevant hardware, software and services portfolio are defined and analyzed in terms of the environmental parameters required by markets and customers. They are then grouped into homogeneous product families based on their underlying technology and specifications, such as the functionality provided, the type of service or software.

The environmental impacts (of our Homogenous Product Families) are quantified using LCAs based on ISO standards. EPDs are used to communicate a portfolio's environmental impact and other environmental indicators that measure circularity. This phase provides the basis for the determination of environmental footprint improvement measures.

During the subsequent **dematerialization** phase, the results of these assessments are interpreted and, where feasible, translated into environmentally optimized design specifications. The 12 Ecodesign criteria are part of these design alternatives and are considered in the Product Lifecycle Management process – for example, secondary materials, repairability, recyclability, upgradability, and energy efficiency – to support dematerialization. The outcomes of the LCA are directly applied, for instance, to inform the development and improvement of new products, strategic planning, public policymaking, or new business models.

From vision to reality
The application of Ecodesign generates learning effects from, and in, the various lifecycle phases over time, which are then considered in subsequent processes. Systematic application of RED can make the vision of all materials being processed in a closed loop become reality: At the same time, the input flow (resources/material, energy) and losses (emissions, waste) of the cycle are reduced to the necessary minimum.

Siemens RED benchmarks are defined in the global internal standards. The pursuit of these criteria and the constant drive towards efficiency and optimization of processes gives us the opportunity to develop new business models throughout the value chain by facilitating transparency, traceability, and data management. By empowering and upskilling employees in this field, we generate added value for individuals as well as for the company and ensure that nobody is left behind on the journey toward more impactful and beneficial business practices and a more sustainable world.

Beginning in 2024, the **Siemens EcoTech** Profile is being awarded to products that outperform their predecessors, harmonized standards, or the market in terms of their environmental impact, based on the 12 Ecodesign criteria.

Ecodesign and digitalization

In what is known as the Twin Transformation, ecodesigned products make a virtue of necessity: The economic growth opportunities made possible by increasing digitalization are coupled with circular, environmentally compatible business models. Just as digital innovations have revolutionized the way we do business, they can also accelerate measures to mitigate climate change and help companies operate more sustainably and efficiently. This transition is being catalyzed by regulatory frameworks and policy packages known as "Green Deals", launched by governments, groups of states, and international bodies.

In 2020, the European Commission, for instance, launched the European Green Deal, a set of policies to reduce greenhouse gas emissions and make Europe climate-neutral by 2050. They are aimed at accelerating the transition toward sustainable growth and a Circular Economy by harnessing -the potential of digital technologies as a way of strengthening the EU's industrial base and supporting business creation and entrepreneurship.

Among other measures, the European Green Deal includes the Circular Economy Action Plan (CEAP) for a cleaner and more competitive Europe. This

plan is geared toward changing consumption patterns in such a way as to avoid waste production starting at the beginning of the value chain. That includes regulating design to make goods and services more durable, reusable, upgradable, and reparable. Manufacturers are encouraged to make products more energy- and resource-efficient and to raise their share of recycled content. Notably, the CEAP includes the digitalization of product information through measures such as digital passports, tagging, and watermarks.

Support for a circular and competitive economy

Today, we support these **decarbonization and further environmental targets** not only with our pledge to carbon neutrality, but with a comprehensive digital portfolio, including optimized energy efficiency and enhanced automation processes that help industries reduce their energy consumption and CO_2 emissions as well as operating costs and waste. We support building owners and operators in minimizing their environmental impact and help them switch to sustainable energy sources with energy performance contracting and decarbonization programs. With data-based intelligent energy systems, we empower our customers to make the transition to distributed energy systems, benefit from electrification, integrate renewables, and roll out large-scale electromobility. Sustainable infrastructure transportation systems powered by Siemens solutions facilitate strong economic growth with better throughput and availability, lower traffic emissions, and sustainable intermodal mobility. With efficient design and carbon-neutral options for non-electrified rail tracks, operators of mobility infrastructure can reduce energy demand and emissions.

Digital solutions deliver transparency

The Digital Product Pass (DPP), which will, inter alia, allow data on materials used and recyclability to be recorded for each product, is an example of how new digital solutions drive efficiency and ecological sustainability. This instrument, part of the EU's proposed Ecodesign for Sustainable Products Regulation (ESPR), is expected to be introduced in the second half of this decade and will become mandatory for all products at a later stage. It can support both policy and business goals by enabling companies to design products suitable for sustainable and circular use, and by informing customer choices with information about environmental parameters.

The DPP will ensure transparency, traceability, and consistency of data throughout the value chain. It will also help companies to standardize monitoring and reporting on sustainability indicators and consider issues from different angles, develop new business models, justify investment decisions, and implement strategies for energy and resource efficiency. The DPP will communicate this information in a reliable and transparent format, serving as a digital supply chain compliance tool for monitoring and reporting on sustainability indicators including the environmental footprint.

The digital twin – a blueprint for optimization

Even before products or services are brought to market, their environmental impact can be assessed using digital twins. These are virtual, real-time representations that facilitate the simulation, testing, and fine-tuning of individual products or whole technology solutions and their operations in digital format. In this way, their sustainability can be determined before imple-

mentation. After commissioning, the digital twin also serves as a digital model against which the product's real-life performance can be measured in order to determine faults, inefficiencies, or wasteful operation for subsequent optimization.

> "We are embarking on a learning trajectory that will help us advance toward the systematic application of Ecodesign to all products."

Here, too, data from all lifecycle phases of a product is used, from the original idea and the production phase to the final product and its practical use, including the processes of suppliers and logistics partners. This means that already in the design phase and across the entire value creation process, proactive, transparent, and durable decisions can be made about optimized resource use, reduction of waste, and lowering of emissions. Moreover, use of a digital twin eliminates the need for the prototyping, testing, and simulation phases and the associated expenditures of resources and energy.

Tools for the Twin Transformation

For the challenging Twin Transformation to succeed, it is necessary to break down the inherent complexity of circularity, Ecodesign, and related approaches – both in conceptual terms and in terms of implementation. Siemens nurtures far-reaching change in the converging fields of digitalization and sustainability, not only through Robust Eco Design of its own products, but also by providing assessment and optimization tools.

A solution such as **SiGREEN,** for instance, allows companies to collect reliable and verifiable data on materials, components, and processes to quantify the CO2 footprint for each of their products in order to identify improvement potential efficiently and securely, and to reduce and/or offset emissions faster. This creates the basis for targeted emission management while preserving the data sovereignty of all participants in the supply chain.

Siemens Xcelerator is another powerful tool: an open digital business platform that enables customers to accelerate their digital transformation. It provides fast, easy, and scalable access to a curated portfolio of connected hardware and software, as well as an extensive marketplace that supports customers' sustainability goals.

Outlook: Robust Eco Design until 2030

Our ambition at Siemens is to apply Robust Eco Design for 100% of relevant hardware, software and services portfolio by 2030. The portion of the portfolio that incorporates Robust Eco Design stands at 54%. Only when the rate of implementation reaches 100% can it be assumed that all relevant elements of the portfolio have completed every phase required to be designated a Robust Eco Design.

The systematic application of this approach – which is transparent and resilient as well as environmentally and climate compatible, and thus future-ready – supports the decoupling of economic development from resource consumption. As such, RED also contributes to maintaining and restoring biodiversity.[4]

Overcoming challenges

In this way, we take account of increasing product requirements in the context of climate neutrality, Circular Economy, absence of pollutants, and biodiversity. These requirements, which will remain at the top of agendas of corporations and their stakeholders, are becoming increasingly challenging. With RED, we can already bring about the transformation toward sustainable business practices and overcome the associated challenges in a collaborative manner today.

Together, we are embarking on a learning trajectory that will help us advance toward the systematic application of Ecodesign to all products. The journey does not end with us: We also help customers and suppliers – a global ecosystem of partners – to achieve accelerated sustainability ambitions.

4 Cf. McKinsey & Co. (December 2022), Nature in the balance: What companies can do to restore natural capital.

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