Supplementary Materials

This supplemental material should not be interpreted as a compilation of strategies defined by various authors but rather as an illustration of how the authors classify information using various hierarchical structures. Thus, X1 represents the highest level of information, whereas X2 and X3 are subclasses of information of X1. Tabs 1, 2, and 3 represent the various possible relationships, showing the many ways of interpreting and structuring information.

Table S1. Classification of design strategies according to relevance in literature.
This table classifies how authors organise design strategies according to relevance. The terms "Strategy X^1", "Strategy X^2" and "Strategy X^3" denote how authors have categorised strategies according to their hierarchical importance.

Authors	**Strategy X1**	**Strategy X2**	**Strategy X3**
Bakker et al., 2014	Prevention	Material efficiency	
		Longer Product Life	
	Reuse	Product repair	
		Product refurbishment	
		Product Remanufacturing	
	Recycling	Product/material recycling	
Arnette et al. 2014	Design for Supply Chain	Design for Procurement	
		Design for Logistics	
		Design for Manufacturing & Assembly	Design for Manufacturing
			Design for Assembly
			Design for Flexibility - Design for Mass Customization - Design for Modularity
			Design for Quality - Design for Reliability
		Design for Supportability	Design for Maintainability
			Design for Serviceability
	Design for Supportability		
	Design for Disassembly		
	Design for Reverse Logistics		
	Design for Environment	Design for Chronic Risk Reduction	
		Design for Energy Conservation	
		Design for Material Conservation	
		Design for Waste Minimization & Recovery	
		Design for Remanufacture, Reuse & Recycling	Design for Reuse
			Design for Remanufacture

			Design for Recycling
	Design for Social Responsibility		
Brennan et al., 2015	Reduce	Durability/Up-weighting	
		Light-weighting	
		Fewer hazardous materials	
		changing consumption patterns	
	Re-use	Cleaning	
		Maintaining	
		Repairing	
		Remanufacturing/refurbishing/ reconditioning	
	Recycle	Upcycle	
		Down-cycle	
		Compost	
	Recovery	AD	
		incineration/gasification/pyrolysis	
Van den Berg et al., 2015	Future proof design (last long and use long)	Long Lasting	Performance
			Reliability
			Durability
		Long in Use	Roadmap fit
			Upgradability
			Adaptability
			Timeless Design
			Anticipate Legislation
	Disassembly (non-destructive)	Connections	Quick and easy disconnect
			Limit use and diversity or fasteners
			Limit use and diversity or tools
		Product Architecture	Simply Product Architecture
			Ease of access to components
			Clarity of Disassembly sequence
	Maintenance (Reuse of the product)	Maintenance	Ease of cleaning
			Ease of Repair
			Allow-on-site maintenance
		Lifetime prognostics	(Online) monitoring for quality, testing maintenance and billing
	Remake (Reuse of the components)	Modularity	Use modular components

			Use standard interfaces
			Back & forwards compatibility
		Reliability assessment	Allow for easy testing of components
		(Reverse) logistics	Product can be returned
			Allow for spare part harvesting
			Local production
	Recycling (Reuse of materials)	Materials	Use preferred/pure materials
			Allow material separability
		Electronic	Get PBC out in one piece
			Easy/fast detection of materials
			Use SMD components
De los Ríos et al., 2016	Whole Systems Design	Radical innovation for sustainability	
		Reduced environmental backpacks	Design for Supply Chain
	Design for Environment		Design for Manufacturing and Assembly
		Clean energy consumption	Biomimicry
		Material selection for sustainability	
	Design for Life Cycle	Design for Reliability	Design for Quality
		Design for Maintenance	Design for Repair / Refurbishment
		Design for Reuse	
			Design for Upgrading
		Design for Component Recovery	Design for Remanufacturing
		Design for Material Recovery	Design for Recycling
			Design for Cascaded Use
Bocken et al., 2016	Design for Slowing Resource Loops	Design for long-life products	
		Design for product-life extension	
	Design for Closing Resource Loops	Design for technical cycle	
		Design for biological cycle	
		Design for dis- and reassembling	
	Business Models for Slowing Loops	Accessing and performance model	
		Extending product values	
		Classic long life	
		Encouraging sufficiency	

	Business Models for Closing Loops	Extending resource value	
		Industrial Symbiosis	
Moreno et al., 2016	Design for resource conservation	Design for circular supplies	Design for closing resource loops - Design for biodegradability - Design with healthy/smart processes/materials
		Design for resource conservation	Design for reduce resource consumption - Design for production quality control - Design for reduction of production steps - Design for light weighting, miniaturizing - Design for eliminating yield loses/material/resources/parts/packaging - Design for reducing material/resource use
	Design for slowing resource loops	Design for long life use of products	Design for reliability and durability - Design on demand or on availability - Design the appropriate lifespan of products/components
			Design for product attachment and trust - Create timeless aesthetics - Design for pleasurable experiences - Meaningful design
			Design for extending product life - Design for repair/refurbishment - Design for easy maintenance, reuse and repair - Design for upgradability and flexibility
			Design for dematerialising products - Design for product-service systems - Design for swapping, renting and sharing.
		Design for multiple cycles	Design for resource recovery - Design for easy end-of-life cleaning, collection and transportation of recovered material/resources - Design for cascade use - Design for (re)manufacturing and dis- and re-assembly - Design for upcycling/recycling
	Whole Systems Design	Design for systems change	Design to reduce environmental backpacks - Design for the entire value chain - Design for local value chains
			Design for Regenerative Systems - Design for biomimicry - Design for biological and technical cycles
Lewandowski 2016	Regenerate	Energy recovery	

		Circular Supplies	
		Efficient buildings	
		Sustainable product locations	
		Chemical leasing	
	Share	Maintenance and Repair	
		Collaborative Consumption, Sharing Platforms, PSS: Product renting, sharing or pooling	
		PSS: Product lease	
		PSS: Availability based	
		PSS: Performance based	
		Incentivized return and reuse or Next Life Sales	
		Upgrading	
		Product Attachment and Trust	
		Bring your own device	
		Hybrid model	
		Gap-exploiter model	
	Optimise	Asset management	
		Produce on demand	
		Waste reduction, Good housekeeping, Lean thinking, Fit thinking	
		PSS: Activity management/outsourcing	
	Loop	Remanufacture, Product Transformation	
		Recycling, Recycling 2.0, Resource Recovery	
		Upcycling	
		Circular Supplies	
	Virtualize	Dematerialized services	
	Exchange	New technology	
Potting et al., 2017	Smart product use and manufacture	R0 - Refuse	
		R1 - Rethink	
		R2 - Reduce	
	Extend lifespan of product and its parts	R3 - Re-use	

		R4 - Repair	
		R5 - Refurbish	
		R6 - Remanufacture	
		R7 - Repurpose	
	Useful application of materials	R8 - Recycle	
		R9 - Recover	
Hollander et al., 2017	Design for Product Integrity	Long Use	Resisting Obsolescence: Design approach for long use
			Design for Physical Durability
			Design for Emotional Durability
		Extended use	Postponing Obsolescence: design approaches for extended use
			Design for Maintenance
			Design for Upgrading
		Recovery	Reversing Obsolescence: design approaches for recovery
			Design for Recontextualising
			Design for Repair
			Design for Refurbishment
			Design for remanufacturing
Ræbild et al., 2017	Flexibility in fit and function		
	Technical durability		
	Logistics vs. user preferences		
	Package range		
	Design for repair		
	Design for disassembly		
Bakker et al., 2018	Design for Product Integrity	Design Approach for Long Use	Design for Physical Durability
			Design for Emotional Durability
		Design Approach for Extended Use	Design for Maintenance and Repair
			Design for Upgrading
		Design approach for Recovery	Design for Recontextualisinag
			Design for Refurbishment
			Design for Remanufacturing

			Design for Recycling
Bovea et al., 2018	Extension of life span	Timeless design	
		Adaptability	
		Upgradability	
	Disassembly	Connectors	Use standardised joints
			Use joints than can be disassembled rather then fixed joints
			Use screws with the same metrics
			Minimise type of joints
			Use easily accessible joints
			Minimise the number of joints
			Minimise the number of tools to be used
			Use standardised tools
		Product structure	Adopt modular designs
			Minimise the number of components
			Be able to quickly identify disassembly joints
			Minimise length of wires and cables
			Size components to make their handling easier
			Facilitate the accessibility of essential components (for their potential reuse/recycling)
			Avoid the disassembly of parts in opposite directions
			Design to make disassembly automatic
	Product reuse	Design to avoid dirt from accumulating	
		Use materials that overcome cleaning processes	
		Minimise the use of parts that require frequent repairs/replacements	
		Use components with a similar life span	
		Incorporate systems to monitor failing components	
	Components reuse	Use standardised components	
		Minimise variations in the appliance	
	Material recycling	Use materials compatible for recycling	
		Unify materials in the components joined by fixed joints	
		Use materials with a low environmental impact (recyclable/low energy content/etc.)	

		Promote monomaterial designs	
		Avoid using surface treatments	
		Label materials	
		Minimise using hazardous materials	
Pieroni et al., 2018	PSS Product-oriented		Product related service
			Product related advice
	PSS Use-oriented		Product lease
			Product renting/sharing
			Product pooling
	PSS Result-oriented		Pat-per-service unit
			Activity management /outsourcing
			Functional result
	Smarter product use and manufacture	Refuse	Abandoning product function
			Same function, radically different product/technology
		Rethink	More intense use or product capacity
		Reduce	Raw materials and sourcing
			Manufacturing and logistics
			Product use and operation
	Extend lifespan or products and parts		Upgrade
			Re-use
			Repair and Maintenance
			Refurbish
			Remanufacture
			Repurpose
	Useful application of materials		Recycle
			Recover
Urbinati et al., 2018	Value Network	Df Reused material	
		Df Redistribute or Reused	
		Df Redistribute or Reused	
		Df Repair and Maintenance	
		Df Remanufacture	

		Df Reassembly	
		Df Disassembly	
		Df Recycle	
	Customer Value Proposition	Df Durability	
		Df Quality	
		Df Reliability	
		Df Esthetic Longevity	
		Df Customization	
		Df Customer's attachment	
De Mattos et al., 2018	Industrial Symbiosis	Work collectively and collaboratively	
	Design of products and services	Co-creating Ecodesign	
	Extending the resource values	Repurposing end-of-life	
		Dismantle equipment and feed its own supply	
	Reverse Supply Chain	Bringing all partners together	
	Integration of information processing	Platforms or collaborative sites	
	Traceability	Implementation RFID	
		Radio-Frequency IDentification	
Kazancoglu et al.2018	Environmental performance	Decreasing Emissions	GreenHouse Gas Emissions
			Air Emissions
			Carbon Emissions
		Decreasing Energy Consumption	Energy Utilization Ratio
			Usage of Green Fuels
			Less Consumption
			Usage of Alternative Energy Sources
		Decreasing Business Waste	Solid Waste
			Liquid/Water Waste
			Total Flow Quantity of Scrap
			Waste generated by Suppliers
			Percent of Materials Recycled or Reused
			Total Amount of Hazardous and Toxic

			Waste
			Usage of Hazardous/Harmful/Toxic Materials
			Compliance of effluents with national and local environmental rules and regulations
		Decreasing Environmental Cost	Cost of Scrap
			Cost of Rework
			Additional Cost for Environmentally Friendly Products and Materials
			Disposal Costs
			Recycling Costs
			Cost of Waste Treatment
			Waste Discharge Fee
			Environmental Accidents Fine
			Cost for Energy Consumption
			Frequency of Environmental Accidents
		Increasing Environmental Revenues	Revenues from Green Products
			Sale of Recycled Materials and Products
			Sale of Scrap and Used Materials
			Sale of Excess Inventories and Materials
			Sale of Excess Capital Equipment
	Economic/financial performance	Cost Oriented	Warranty Cost
			Transportation Cost
			Labor Cost per Hour
			Training and Orientation Cost
			Manufacturing Cost
			Cost of Raw Materials
			Cost of Procurement
		Revenue-Oriented	Average Profit from Green Products
			Profit Growth Rate for Green Products
			Average Return on Sales from Green Products
			Average Return on Investment from Green Products

			Average Return on Net Assets from Green Products
	Operational performance	Increase in Quality	Customer Rejection Rate
			Finished Product Yield Rate
			In Plant Defect Rate
			Total Quality Environmental Management
			Employee Satisfaction from Green Processes
			Poka-Yoke Equipment
			Continuous Improvement System
			Scrap Rate
			Rework Rate
		Increasing Efficiency	Overhead Expense
			Operating Expense
			Capacity Utilization
			Energy Efficiency
		Improving Green Manufacturing	Redefine Operation and Production Processes
			Use of Non-Toxic and Hazardless Materials in Production
			Use of Recyclable Materials in Production
			Use of Recycled Materials in Production
			Waste Reduction and Pollution Monitoring Equipment
			Structure for Easy Disassembly
			Monitoring and Maintenance System
			Inventory Levels
			Reduction in Operation Steps
			Reduction in Number of Hazardous Production Processes
			Reduction in Number of Hazardous Machines
			Reduction of Health and Safety Risks
			Green Technology Adoption
			Structure for Easy Assembly

			Scheduling and Input/Output Control in Production Planning and Control for Waste Reduction
			Process Design for Reducing Energy Consumption
			Process Design for Minimization of Waste
			Reducing the Noise Pollution
			Use of Renewable Energy Resources
			Acquisition of Green Production Technology/ Equipment
			Cooperation with Customers for Green Production
		Improving Green Packaging	Use of Non-Toxic and Hazardless Materials in Packing
			Use of Recyclable Materials in Packing
			Use of Recycled Materials in Packing
			Cooperation with Customers for Green Packaging
			Cooperation with Suppliers for Green Packaging.
			Use of Eco-Label on Package
			Labeling for Retrieval Purposes
		Improving Green/Eco Design	Reduction in Energy Consumption
			Reused Materials in New Designs
			Recycled Materials in New Designs
			Reduction of Resource Consumption and Waste Generation during the Use of Product
			Reduction of Hazardous Manufacturing Process and materials
			Less Volume for Storage
			Easy Setup for Energy Saving
			Longer Service/Product Life
			Reduction of Material Consumption
			Design for Remanufacturing
			Concurrent Engineering
			Cooperation with Customers for Eco-Design
			Cooperation with Suppliers for Eco-Design

			The Number of Patents for Green Products
			Life Cycle Costing
			Life Cycle Assessment
	Logistics performance	Improving Green Logistics	On time delivery
			Eco-driving to decrease fuel consumption
			Just in time for logistics
			Order cycle time
			Environmental friendly transportation
			Recyclable or reusable packaging/containers in logistics
			Order fulfillment
			Delivery dependability
			Modal split (weight of goals transported by road)
			Average handling factor (Road tons-lifted)
			Average length of haul (tons-km)
			Average load on laden trip (weight/volume)
			Average percentage of empty running
			A recycling system for used and defective products
			Products with take-back policies
			Mode of transport
			Greener vehicles
			Route optimization
			Vehicle utilization
			Fuel efficiency
		Improving Reverse Logistics	Remanufacturing of materials
			Reusing and recycling of materials
			Reduction of time for recycling
			Incorporating third party logistics for customer cooperation
			The number of customers cooperated for reverse logistics
			Design for reverse logistics

		Improving Green Purchasing	Eco labeled materials and products
			Environmentally friendly materials
			Supplier education
			Supplier support
			Cooperation with suppliers for green purchasing
			Understand environmental risk and responsibilities with suppliers
			Environmentally-audited suppliers
			Certified suppliers other than ISO 1400
			ISO14000 certified suppliers
			Providing design specifications to suppliers with environmental requirements
			Second-tier supplier environmental evaluation
			Requiring certification of testing for green product conformance
			Urging/forcing suppliers to conduct environmental actions
	Organizational performance	Improving Green Image	Number of related fairs/ symposiums participated
			Reduction of environmental accidents
			Improved employee and community health
			Sponsoring to environmental events/collaboration with ecological organizations
			CSR activities on GSCM
		Incorporating Environmental Management	Commitment from managers
			Commitment from employees
			Green initiatives and eco-service
			A Clear environmental policy statement
			Cross functional teams for environmental management
			Environmental auditing
			Keeping the website updated on environmental issues
			Activity report on environmental management
			Taking stakeholders' opinions and requirements into consideration

			Business ethics and code of conduct
			R&D budget on green products
			Compensation/incentive linked to environmental factors
			Environmental management on accounting practices
			Training for workers on environmental issues
			Employee suggestion system on environmental issues
			Participation in environmental programs and research projects
			Increase the proportion of employee recommendations and proposes for improvement in quality, social and environment health and safety performance
		Green Information Systems	Monitoring the environmental information (such as toxicity, energy used water used, air pollution)
			Accurate and prompt information exchange between trading partners
			Environmental information sharing with customers
			Environmental information sharing with suppliers
			Customer relationship management related with GSCM
			Informing trading partners prior to changing environmental need
	Marketing performance	Increasing Customer Satisfaction	After sales service performance
			Out of stock for green products
			Service response rate
			Customer returns
			Customer lost rate
			Number of customers retained
			Number of recalls
		Improving Cooperation/Collaboration with Customers	Sharing common goals with customers
			Resolve environmental problems with customers
			Understand environmental risk and responsibilities with customers
			Cooperation with customers to decrease environmental impact of operations
			Communicating firm's strategic needs to customers

			Cooperation with customers to encourage green purchasing behavior
		Marketing Measures	Conservation of energy and resources in marketing mix
			Use of environmental arguments in marketing
			Customer profitability on green products
			Number of green products
			Number of new customers on green products
			Customer complain rates on green products
			Average market share growth on green products
			Average sales growth (volume and dollar) on green products
			Increasing customer value on green products
			Budget on green marketing activities
Blomsma et al., 2019	Reinvent (Refuse)		
	Rethink & reconfigure	Multi-flow offering – cascade materials, parts & products	
		Long life products – through- life support	
		Access or availability – incl. shared use	
		Result & performance – service, not product	
	Restore, reduce & avoid	Raw materials & sourcing - Improve circularity potential and efficiency in the sourcing process (Mestre and Cooper, 2017)	Sourcing of renewables
			Sourcing of recyclable materials
			Secondary sources (recycled materials, Industrial Symbiosis, other cascades).
			Restorative sourcing (Use former 'wastes' as input: Landfill re-mining or using ocean plastics)
			Use of non-toxic or benign materials (to facilitate re-absorption in natural cycles)
			Use the lowest suitable grade of materials suitable (Reserve the highest-quality resources for the most demanding task, and use used resources further down the chain)
		Manufacturing - Improve circularity potential and process efficiency in product manufacture through consuming fewer natural resources or energy, aim for 'gentani' (the absolute minimum input required to run a process) (Potting et al., 2017)	Lean manufacturing & cleaner production (use less energy and materials, treat wastes, etc)
			Rework (pre-user refurbishment or remanufacture)
			Recycle (pre-user recycling

			Cascade (find uses for manufacturing waste: internally/ at other facilities (Industrial Symbiosis))
			Recover (energy recovery, or recovery of biological nutrients)
		Product use & operation - Improve circularity potential and efficiency in product use and operation through wiser use and operation of products (usually enabled by digital technologies), and aim for 'gentani' (the absolute minimum input required to run a process) (Potting et al., 2017; Reike et al., 2018)	Enable product longevity through high product integrity and robustness
			Use idle product capacity (historical usage data can be used for improvements such as better scheduling (of downtime), and (give insight into the possibilities for) pooled or shared use)
			Low consumables of energy, water and materials during product use and operation
		Logistics - Improve process efficiency in logistics operations, aim for 'gentani' (minimum input into a process (Greenbiz, 2014)	Combine forward & return logistics.
			Incentivize eco-friendly driving and transport
			Minimize, reuse or recycle (transit) packaging
		Energy - Improve energy efficiency and use clean(er) sources of energy (Cullen, 2017; Mestre and Cooper, 2017).	Use less energy
			Renewable energy
	Recirculate (Parts & products)	Upgrade	Aesthetic upgrades (i.e. changing the coat or sleeve of a product due to a new preference)
			Functional upgrades (i.e. software upgrades, hardware upgrades)
		Repair & maintenance	Providing a product with a service, which may involve the lubrication of critical parts, checking fasteners, the tension of chains and cables, the replacement of worn-out parts, etc
			Repair may involve the restoration or replacement of faulty parts and components.
		Reuse	Selling used goods on platforms such as E-bay
			Return and resale of second hand goods through stores, such as Patagonia and Bergans
			The xStorage Home system (by Nissan and Eaton) gives old lithium-ion batteries from Nissan Leaf a second life inside of homes and businesses as backup and solar storage batteries.
		Refurbish	
		Remanufacture	
		Repurpose	
	Recirculate (Materials)	Recycle	
		Cascade	

		Recover	Incineration, pyrolysis or anaerobic digestion (recovery of energy).
			Composting (recovery of biological nutrients).
Suarez-Eiroa et al.2019	Adjusting inputs to the system to regeneration rates	Substituting non-renewable by renewable inputs (e.g., bio-based materials, renewable energy)	
		Substituting renewable materials with low regeneration rates for other with faster regeneration rates	
		Adjusting taxes and subsidies of technology, products and materials based on their resource regeneration rates	
		Saving energy and materials (i.e. improving energy efficiency, resource productivity, virtualizing products, etc.)	
		Fostering renewable mobility (i.e. walking, bicycle, renewable fuels, etc.)	
	Adjusting outputs from the system to absorption rates	Substituting materials and processes which produce technical outputs by those which produce biological outputs	
		Substituting processes for those with lower waste generation rates (i.e. more eco-efficiency processes)	
		Adjusting taxes and subsidies of technology, products and materials based on their waste generation rates	
	Closing the system	Separating biological and technical wastes properly	
		Remanufacturing products and components	
		Promoting and improving downcycling, recycling and upcycling of wastes (i.e. logistics, take-back systems, technology, etc.)	
		Promoting energy recovery by converting waste into heat, electricity or fuel	
		Promoting Extended Producer Responsibility	
	Maintaining the value of resources within the system	Interconnecting stages (i.e. redistributing second-hand goods)	
		Promoting industrial symbiosis (i.e. establishing standards, cascading, by-products, etc.)	
		Increasing durability (i.e. practical guides for reparability, preventive and corrective maintenance, repurposing, etc.)	
		Reducing obsolescence (i.e. updating software)	
	Reducing the system's size	Informing consumers properly (i.e. eco-labelling, product labelling, product declarations, etc.)	
		Expanding the Extended Consumer Responsibility	
		Promoting functional service economy and sharing economy (i.e. collective mobility)	

		Promoting green procurement (i.e. local products, season products, etc.)	
		Adjusting selling doses to consumer doses	
	Designing for CE	Eco-design (i.e. optimizing packaging, improving durability, etc.)	
		Designing transparent, reproducible and scalable products to build the same products in other places based on local resources	
		Thinking about practical utilities and consumer preferences (customization/made to order)	
		Designing new business models and strategies	
		Designing new methodologies to guarantee a continual improvement	
		Designing projects to promote sustainable development and circular economy	
	Educating for CE	Adjusting educational curricula to the current challenges	
		Promoting knowledge, skills, capabilities and values that ensure the proper performance of circular economy	
		Promoting habits and individual actions in favor of circular economy	
Kristensen et al., 2020	Recycling		
	Remanufacturing		
	Reuse		
	Resource Efficiency		
	Disassembly		
	Lifetime extension		
	Waste management		
	End-of-life management		
	Multidimensional indicators		
Fernandes Aguiar et al.,		Design for Dematerializing/ repurposing products	Design for PSSs
			Design for Exchange
			Design for Adaptability
			Design for Repurpose
			Design for Remake
			Design for Recontextualizing
	Design for Resource Conservation	Design for reduce resource consumption	Design for Product Quality

			Design for Reliability
			Design for reduce Weight/minimization
			Design for Fault diagnosis and failure modes
			Design for Energy Efficiency
			Design for Environment
			Design for Sustainability
			Design for Modularity
			Design for Standardization and compatibility
			Design for Reduce
			Design for Demand or on Availability
		Design for Closing Resource Loops	Design for Biodegradability
	Design for System Change	Design for Regenerative System	Design for Biomimecry
			Design for Biological Cycle
			Design for Technical/Technological Cycle
			Design for Entire Value Chain (circular supply)
Moreno et al., 2017	Resource Conservation	Design for energy conservation	Use clean energy consumption
			Reduce energy consumption in manufacture (eliminate yield losses)
			Improve manufacture (production steps, supply chain)
			Use processes suitable for low scale production
		Design for material conservation and eliminate waste	Select the best materials (non-toxic, pure if possible)
			Choose local materials (no-rare to avoid scarcity)
			Choose local materials (no-rare to avoid scarcity)
			Eliminate unnecessary parts and sub-assemblies
			Reduce material (light weighting)
			Reduce or eliminate packaging
			Reduce the size of components (miniaturise)
			Reduce the size of components (miniaturise)
			Avoid toxic adhesives, use

			easy-mechanic joints (fasteners, visible joints)
			Use pure materials to allow biodegradability
	Life Cycles (end-of-life)	Design for optimising/extend product life	Assure reliability (quality)
			Allow reusabilit
			Encourage maintenance (repair/refurbish)
			Ease assembly/disassembl
			Standardise parts for compatibility (modularity)
			Remanufacture
		Design for multiple life cycles	Recover material (easy to clean, collect and transport)
			Allow cascade use
			Motivate the user to recycle
			Assure spare parts availability
	Whole System Design	Design for sustainability	Shift the ownership of products into a service (swap, rent, share)
			De-materialise products into digital platforms
			De-materialise products into digital platforms
			Strengthen local industry
			Create regenerative systems (biomimicry)
			Care about social impact
			Create a wealth through a good business practice (improve cost-benefit relationship)
			Develop a trace-and-return system
	Customer	Design for users	Customise to wants and needs of each person
			Enhance durability (avoid built-in obsolescence)
			Develop attachment/loyalty (experience, meaningful design)
			Reduce waiting times in delivery to consumer
			Based on long-lasting trends, no ephemeral fashion (timeless aesthetics)
			Implement poka-yoke principles to ease use
	Development	Design for the present towards the future	Use mobile technologies

			Use Machine-to-Machine communications (M2M)
			Use cloud computing
			Use social media technology
			Use big data analysis
			Use new material (intelligent, organic)
			Use 3D printing (avoid subtracting technologies)
			Create multi-functional teams to consider different aspects in the design

Table S2. **Classification of design strategies according to product life cycle phases in literature.** This table classifies how authors organise design strategies according to their respective life cycle phases. "Life Cycle Phases" defined how the authors referred to the various phases of the supply chain, while "Strategy X^1" and "Strategy X^2" described primary and secondary design strategies for each phase.

Authors	**Life Cycle Phase**	**Strategy X1**	**Strategy X2**
Brezet et al 1998	New concept development	Dematerialisation	
		Shared use of product	
		Integration of functions	
		Functional optimisation of product	
	Product Component Level	Selection of low-impact materials	Cleaner materials
			Renewable materials
			Lower energy content materials
			Recycled materials
			Recyclable materials
		Reduction of materials usage	Reduction in weight
			Reduction in (transport) volume
	Product Structural level	Optimisation of production techniques	Alternative production techniques
			Fewer production steps
			Lower/cleaner energy consumption
			Less production waste
			Fewer/cleaner production consumables
		Optimisation of distribution system	Less/ cleaner/ reusable packaging
			Energy-efficient transportation mode
			Energy-efficient logistics
		Reduction of impact during use	Lower energy consumption
			Cleaner energy source
			Fewer consumables needed
			Cleaner consumables
			No waste of energy/consumables
	Product System Level	Optimization of initial lifetime	Reliability and durability
			Easier maintenance and repair
			Modular product structure
			Classic design
			Strong product-user relation
		Optimization of end-of-life system	Reuse of product

			Remanufacturing/refurbish
			Recycling or materials
			Safer incineration
Umeda et al., 2012	Pre-manufacture	Use of recycled Materials	
		Use of less energy intense materials	
		Environmentally conscious component selection	
		Use of renewable materials	
	Manufacture	Use high-throughput process	
		Use material saving process	
		Overhead reduction	
	Transportation/distribution	Improve Logistics	
		Low volume/weight	
		Use recycled materials for packaging	
	Use	Low energy consumption	
		Design for Maintenance/long life	
	Disposal	Design for Disassembly	
		Material Quality Preservation	
White et al., 2013	Innovation	Rethink how to provide the benefit	
		Design flexibility for technological change	
		Provide product as service	
		Serve needs provided by associated products	
		Share among multiple users	
		Design for mimec biological systems	
		Use living organisms in product system	
		Create opportunity for local supply chain	
	Reduced Material Impacts	Avoid Materials that damage human or ecologica hea	
		A Void materials that deplete natural resources	
		Minimize quantity of materials	
		Use recycled or reclaimed materials	
		Use renewable resources	
		Use materials from reliable certifiers	
		Use waste byproducts	
	Manufacturing Innovation	Minimize manufacturing waste	
		Design for product quality control	

		Minimize Energy use in Production	
		Use carbon neutral or renewable energy sources	
		Minimize number of production steps	
		Minimize number of components/ materials	
		Sick to eliminating toxic emissions	
	Reduced Distribution impacts	Reduced product and packaging weight	
		Reduced product and packaging volume	
		Develop reusable packaging systems	
		Use lowest- impact transport system	
		Source or use local materials and production	
	Reduce Behaviour and use impact	Design to encourage low-consumption behaviour	
		Reduced energy during use	
		Reduced Material consumption during use	
		Seek to eliminate toxic emissions during use	
		Design for carbon-neutral or renewable energy	
	System longevity	Design for durability	
		Foster emotional connection to product	
		Design for maintenance and easy repair	
		Design for reuse and exchange of products	
		Create timeless athletic appeal	
	Transitional System	Design upgradable product	
		Design for second life with different function	
		Design for reuse of components	
	Optimize End-of-Life	Design for Fast Manual or automated disassembly	
		Design recycling business model	
		Use recyclable non-toxic materials	
		Provide ability to biodegrade	
		Integrated methods for used product collection	
		Design for safe disposal	
Go et al. 2015	Product Design Considerations	Environmental performance measurements	
		All cost considerations	
		Resource minimization and elimination	
	Packaging Design	Resource minimization and elimination	

	Considerations	Biodegradability	
		Reusability	
		Recyclability	
		Application of industry standards	
	Product Manufacturing Design Considerations	Choosing cleaner production processes	
		Improving quality	
		Choosing clean power sources	
	Material Design Considerations	Material selection	Choosing of abundant renewable resources
			Choosing sustainably harvested materials
			Choosing recyclable materials
			Avoiding hazardous substances
			Reducing material process energy
		Material employment	Elimination of material waste
			Dematerialisation
			Simplification of products
	Product Distribution Design Considerations	Choosing cleaner transportation methods	
		Reducing transportation of products	
	The Product Use Design Considerations	Reducing product energy	
		Reducing what a product consumes	
		Keeping products clean	
	The Product Service Design Considerations	Make service easy	
		Use Benign servicing consumables	
	Product EOL Design Considerations	Design for Disassembly	
		Design for Recycling	
		Design for Reuse	
		Design for Remanufacturing	
		Design for Biodegradation	
Mestre et. al., 2017	Material extraction (Selection of low impact materials)	Slow the loop	Cleaner materials
			Renewable materials
			Lower energy materials
			Recyclable materials
			Recycled materials
	Processing (Reduction of the material use)		Reduction in weight
			Reduction in volume (transport)

	Manufacturing (Optimisation of production techniques)		Alternative production techniques
			Fewer production steps
			Lower/cleaner energy consumption
			Less production waste
			Fewer/cleaner production consumables
	Transportation (Optimisation of distribution system)		Less/cleaner/reusable packaging
			Energy-efficient transport mode
			Energy-efficient logistics
	Use (Reduction of impact during use)		Lower energy consumption
			Cleaner energy source
			Cleaner consumables
			Fewer consumables needed
			No waste of energy/ consumables
	Product life extension (Optimisation of initial lifetime)		Reliability & durability
			Easier maintenance & repair
			Upgradability & adaptability
			Standardization & compatibility
			Modular product structure
			Dis- and reassembly
			Classic design
			Strong product-user relation (e.g. emotionally durable design)
	End-of-life disposal (Optimisation of end of life system)		Reuse of product
			Remanufacturing/ refurbishing
			Recycling of materials
			Safer incineration
	@ – Development of new concepts / Product design review / Other design concepts		Dematerialisation
			Shared use of the product (ownership)
			Integration of function
			Functional optimisation of product (components)
	Material extraction (Selection of low impact materials)	Close the loop	Recycled materials
			Recyclable materials
			Biodegradable materials
			Lower energy materials
			Photodegradable materials

			Renewable materials
			Cleaner materials
	Processing (Reduction of the material use)		Reduction in weight
			Reduction in volume (transport)
	Manufacturing (Optimisation of production techniques)		Alternative (optimised) production techniques
			Fewer production steps
			Lower/cleaner energy consumption
			Minimal production waste
			Fewer/cleaner production consumables
			Renewable material & energy resources
			Industrial symbiosis
	Transportation (Optimisation of distribution system)		Less/reusable/ biodegradable (zero waste) packaging
			Energy-efficient transport mode
			Clean & efficient energy logistics
			Elimination of logistics– “do it yourself” (e.g. 3D print at home with starch-based polymers)
	Use (Reduction of impact during use)		Lower energy consumption
			Clean energy source
			Clean consumables
			Fewer consumables needed
			No waste of energy/ consumables
			Upgradability (modularity)
	Product life extension (Optimisation of initial lifetime)		Reliability & durability b.
			Easy maintenance & repair
			Upgradability & adaptability
			Standardisation & compatibility
			Modular product structure
			Dis- and reassembly g.
			Classic design
			Service for function maintenance (i.e. company takes back end-of-life product, replaces with new)
	End-of-life disposal (Optimisation of end of life system)		Biodegradability
			Remanufacturing/ refurbishing
			Recycling of materials

			Recollection of product for dismantling/material extraction
			Compostability f. Nutritional value (waste=food)
			Photodegradation h. Reuse of product
			Repurpose of product function
			Recollection system for product
	@ – Development of new concepts / Product design review / Other design concepts		Dematerialisation
			Shared use of product (ownership)
			Integration of function
			Functional optimisation of product (components)
			Function as service (not product)
			Circular business model
Prieto‑Sandoval et al., 2018	Take	Assignment: - Systematization: Material traceability; Green procurement; Corporate social responsibility; ECO2: Avoidance of the use of toxic materials. Process and product transparency; ECO‑Innovative: Embrace the use of sustainable materials; Leading green company: Use of sustainable and fully recoverable materials;	
	Make/transform	Assignment: Training and of employees in sustainability issues; Systematization: Minimizing the environmental impact by the resources optimization ECO2: The use of sustainable energy sources Prevention of environmental damage; ECO‑Innovative: The design of circular and sustainable products; Collaborative product design. Ecological modernization; Leading green company: Zero‑waste processes; s Company digitalization toward industry 4.0 improvements;	
	Distribute	Assignment: - Systematization: - ECO2:Optimization of stock, routes, and space; ECO‑Innovative: Local market promotion; Leading green company: Collaborative reverse logistics	
	Use/consume	Assignment: Reaction to consumer requests on environmental issues; Systematization: Products certifications	

		such as eco‑labels; ECO2:Optimization of stock, routes, and space; Communication of environmental initiatives; ECO‑Innovative: Green marketing strategy; Market segmentation Leading green company: Product system services implementation;	
	Recover	Assignment: - Systematization: - ECO2:Waste management and in the suitable treatment of the various types of waste; ECO‑Innovative: Valorization of waste and energy; Leading green company: Valorization and commercialization of by‑products and surplus electrical and/or heat energy to another consumer;	
	Industrial symbiosis	Assignment: - Systematization: - ECO2: - ECO‑Innovative: Integration with other stakeholders to share materials and potential by‑products; Leading green company: Complete integration of resources and energy with other stakeholders;	
Kalmykova et al., 2018	Material Sourcing	Diversity and cross-sector linkages	
		Energy production/Energy autonomy	
		Green procurement	
		Life Cycle Assessment (LCA)	
		Material substitution	
		Taxation	
		Tax credits and subsidies	
		Customization/made to order	
		Design for disassembly/recycling	
		Design for modularity	
		Eco design	
		Reduction	
	Design	Customization/made to order	
		Design for disassembly/recycling	
		Design for modularity	
		Eco design	

		Reduction	
	Manufacturing	Energy efficiency	
		Material productivity	
		Reproducible & adaptable manufacturing	
	Distribution and Sales	Optimized packaging design	
		Redistribute and Resell	
	Consumption and Use	Community involvement	
		Eco-labelling	
		Product as a service or Product Service System	
		Product labelling	
		Re-use	
		Sharing	
		Socially responsible consumption	
		Stewardship	
		Virtualize	
	Collection and Disposal	Extended Producer Responsibility (E.P.R)	
		Incentivized recycling	
		Logistics/Infrastructure building	
		Separation	
		Take-back and trade-in systems	
	Recycling and Recovery	By-products use	
		Cascading	
		Downcycling	
		Element/substance recovery	
		Energy recovery	
		Extraction of bio-chemicals	
		Functional recycling	
		High quality recycling	
		Industrial symbiosis	
		Restoration	
		Upcycling	
	Remanufacture	Refurbishment/Remanufacture	
		Upgrading, Maintenance and Repair	
	Circular Inputs	Bio-based materials	

Table S3. **Classification of design strategies according to life cycles in literature.**
This table classifies how authors organise design strategies according to their respective life cycles. "Loop X" describes the life cycle, so 1 denotes the initial loop (L^1), whereas 2+ denotes the second loop and onwards ($L^{2, 3, etc.}$). "Strategy X1" and "Strategy X2" describe the primary and secondary design strategies for each life cycle.

Authors	**Loop X**	**Strategy X1**	**Strategy X2**
Sirkin et al., 1994	1	Material Selection	Material selection and appropriate fit
			Material selection, relinking and resource regeneration
		Separability of materials	Avoid combined materials whenever possible
			Use reusable connector links
			Design with as few connector links as possible
			Minimizing the number of different materials in a product eases separability
			Use modular systems, exchangeability and reduction of number of materials used.
			Facilitate repair without special equipment
			Include material identification
		Product durability	Maximise the lifetime of the resources used (multi-usable components)
			Product reliability
			Adjustment of product lifetime
			Use wear indicator
			Use maintenance indicators
			Design for repairability
			Design for product renovation
			Design for adaptability of the product
	2 +	Relinkability and cascadability	Keep the next order type in mind
			Be informed about the existence of re-collection system for the re-use paths of chosen resources
			Take into consideration that by-products caused by use of the product must be relinked, neutralized or reuse
			Prioritize designing through the use of single materials first; thereafter, compatible materials
			Avoid designs or process which may have toxic effects during or at the end of the product life

		Reducing resource metabolism	
		Time-sharing of products	
		Integrating similar functions	
		Separating functions	
Guiot et al., 2010	2+	Critical motivations	Avoidance of conventional channels
			Ethical and ecological dimension
			Anti-ostentation
		Experiential motivations linked to the nature of the offering	Originality
			Nostalgic pleasure
			Self-expression
			Congruence
		Experiential motivations linked to channel characteristics	Social contact
			Stimulation
			Treasure hunting
		Economic motivations	Wish to pay less
			Search for fair price
			Bargain hunting
			Gratificative role of price
Daae et al., 2018	1	Maintenance/longevity	Control
			Obtrusiveness
			Encouragement
			Meaning
			Direction
			Empathy
			Importance
			Timing
			Exposure
	2 +	Reuse	Control
			Obtrusiveness
			Encouragement
			Meaning
			Direction
			Empathy
			Importance
			Timing

			Exposure
		Refurbish	Control
			Obtrusiveness
			Encouragement
			Meaning
			Direction
			Empathy
			Importance
			Timing
			Exposure
		Recycling	Control
			Obtrusiveness
			Encouragement
			Meaning
			Direction
			Empathy
			Importance
			Timing
			Exposure
Shafiee et al., 2013	2+	Second-hand	Long warranty policy of a second-hand product
			Upgrade action of a second-hand product
			Sale price of a second-hand product
Connor-Crabb et al., 2016	2+	Seasonality	
		Multi-functionality / modularity	
		Alterability / repairability	
		Physical / emotional durability	
		Classic design	
		Design inspiration	
		Custom sizing	
Weelden et al., 2016	2+	Attract consumers	Arouse interest to stimulate consideration of refurbished products
		Convinced of the value of a refurbished	Demonstrate the value of refurbishment to shift risk-benefit balance
		Involve consumers in the use and growth of refurbishment	Use consumer power to reinforce awareness and trust building
Wallner et al., 2020	2+	Timeless Designs	Exceptionally Beautiful Designs

			Nostalgia Evoking Designs
			Simplistic Design