Circular Product Design

Concept Paper

Developed with ASI's Circularity Working Group

November 2024

Contents

1. Introduction

A Circular Economy (CE) is an economic system that adopts a systemic approach to the maintenance of circular resource flows (ISO 59004:2024[1]). It focuses on recovering, retaining, or enhancing resource value, all while delivering services to communities and contributing to sustainable development. Unlike the traditional linear resource model—where materials are extracted, used, and then discarded—the circular model emphasizes minimizing material inputs and mitigating waste, emissions, and energy leaks. This approach aims to be in harmony with the rhythm of the natural world, where efficient ecosystems constantly adapt to make use of all available resources and to avoid waste (of nutrients, energy, abiotic resources, etc.).

A critical element in the realisation of circular economic systems is **Circular Product Design**, which seeks to source (multiple and mixed) materials already circulating in the technosphere and pre-empts the resource efficient use and reuse of those service-delivering products and recovery of their constituent parts and materials.

The transition to circular design in aluminium production and usage involves applying CE principles across the product lifecycle, aiming to leave a positive legacy that extends beyond mere material procurement. The principles of ISO 59004 that underpin a circular economy are crucial and must be aligned with the practices of aluminium design, production, reuse and recycling. These principles include:

- **Systems thinking:** Recognizing the interconnected impacts of aluminium production, usage, and disposal. From inception, aluminium products should be envisioned as part of a broader ecosystem, integrating use phase and end-of-life considerations as a fundamental aspect of product design.
- **Value creation:** The goal is to generate societal value that transcends the functional first use of aluminium products. Designs should contribute additional socio-economic and environmental benefits, like enhanced modularity and easier sorting after product use, thus benefiting future generations.
- **Value sharing:** Engaging stakeholders throughout the value chain ensures that the benefits of circular aluminium products are distributed more widely. This sharing of created value supports community well-being, promotes equity, and bolsters collaborative efforts towards sustainable futures.
- **Resource stewardship:** Efficient and respectful use of materials is a cornerstone of circular design. While the aluminium industry (and all sectors) and its customers should seek to minimize reliance on virgin resources, they should also ensure that such resources are not lost and wasted at the end of a product's (first) life. With primary aluminium still required to meet up to 50% of global demand by 2050, even with near 100% recycling rates, it is imperative that as many products are reused and as much aluminium recovered as possible, conserving resources for future needs.

[1] ISO 59004:2024 Circular economy — Vocabulary, principles and guidance for implementation (https://www.iso.org/standard/80648.html)

- **Resource traceability:** Tracking the flow of materials throughout their lifecycle can support responsible sourcing and effective cycling. The ability to map the movement of products and materials through a value chain in principle and a given supply chains in practice fosters accountability and transparency, which are essential for the integrity of CE practices.
- **Ecosystem and community resilience:** Aluminium industry practices should regenerate and protect the value of ecosystems while also considering the impacts on local communities. Design strategies must not only focus on the resilience of local ecosystems, promoting biodiversity and natural regeneration, but also assess and mitigate potential negative socio-economic impacts on workers, neighbours, and product users, such as health and wellbeing, adverse effects on cultural heritage and curtailment of traditional or dependent economic practices (e.g. foraging, fishing, etc)

Following these principles in product design and development can ensure that products, including those that include aluminium, are fit for their next use in circular pathways[2]. This strategic focus can shift the aluminium industry from a produce-consume model to a resource lifecycle redesign approach. Doing so allows for waste reduction strategies like repurposing aluminium scrap and turning waste streams into valuable products. Furthermore, product design prioritises the minimization of hazardous materials, aligning with a risk-based approach. This strategy adheres to both regulatory compliance and the broader goals of protecting human and ecosystem health under safe and sustainable design regulations. These methods reduce disposal costs and boosts industry sustainability and profitability.

This paper sets the stage for detailed guidelines on implementing circular design principles, as explored by ASI's Circularity Working Group.

2.Context and Application of Circular Design Principles

ASI's Performance Standard v3, particularly Criterion 4.2, emphasizes the integration of clear sustainability objectives in the product design and development process, to enhance circular economy outcomes. This criterion underscores the need for designing products that are prepared for their next use phase and can be actively cycled through their intended circular pathways.

Criterion 4.2 is applicable across various segments of the aluminium industry, including:

- **Semi-Fabrication:** The focus is on designing semi-finished products like sheets, foils, and extrusions that can generate less scrap during transformation processes, are easier to recycle, repurpose, or reintegrate into new production cycles.
- **Material Conversion:** The emphasis is on transforming semi-finished aluminium products into components that are designed for easy disassembly and recycling, ensuring that materials can re-enter the production cycle with minimal processing.

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[2] Circular pathways refer to the processes and strategies designed for extending resource use to reduce waste in a closed loop system. Products, components, and materials can cycle through various stages of use and reuse instead of following the linear model of "take, make, dispose."

- **Other Manufacturing:** Encompasses the creation of aluminium-containing products where circular design principles can significantly reduce the reliance on virgin materials and enhance the product's lifecycle through better design for reusability, repairability, and recyclability.

2.1. Desired outcomes of applying circular design principles

This section highlights key objectives that facilitate a shift towards sustainable, circular product design, detailing essential outcomes that enhance industry circularity and align with sustainable development principles.

Circular economy outcome category	Desired outcomes
Design strategies for circular outcomes	Products are designed with features such as reuse, modularity, durability, safety and ease of disassembly, which facilitate their integration into circular pathways.
	Appropriate circular pathways are determined for materials once products reach the end of their current use, ensuring seamless transition into new life cycles.
Material dynamics for circularity	By using recycled or renewable materials, entities contribute to a stronger market demand for such materials, helping to close the loop and minimize the negative impacts of virgin material use.
	Materials that are likely to retain value through multiple cycles are prioritized, enhancing the overall sustainability of the products.
Knowledge and information sharing	Entities gain a comprehensive understanding of the circular potential of their products across all levels of the organization, identifying both opportunities and solutions to enhance the cycling of resources.
	Information on how to handle products at the end of their use phase is made available to the public, increasing the likelihood of effective material recovery and recycling.
Chemical and material transparency	An increasing percentage of a product's material and chemical composition is disclosed, enhancing the ability to assess potential risks and foster the development of safer chemical handling practices.
	Strategies are implemented to reduce the risk associated with the use of hazardous chemicals and emissions in the supply chain, while demonstrating measurable progress in these reductions.

2.2. Maturity levels

Maturity levels provide a valuable framework for assessing the implementation and effectiveness of design for circularity practices within an organization. These levels can help businesses understand their current position in incorporating circular economy principles into their operations and guide them on potential improvements. By classifying practices into leading, better, common, and poor, organizations can evaluate how well they are doing in designing products and processes that facilitate a circular economy. Here's a general summary of each category tailored to design for circularity at the current time (categories can change over time as the sector and the global economy transforms into a more circular model):

Practice level	Description
Leading practices	These represent the pinnacle of innovation in circular design, introducing groundbreaking technologies and organizational processes that redefine industry standards. They aim to significantly enhance the sustainability and resource efficiency of products throughout their lifecycle. While these practices often involve high risks, such as substantial initial investment costs, technological uncertainties, and market acceptance challenges, they also offer potentially high rewards.
Better practices	Established, effective methodologies that are informed by current best knowledge and are neither experimental nor obsolete. These practices are characterized by their documented success in real-world applications and are supported by robust performance metrics. They balance innovation with practicality, offering moderate risks and reliable results in promoting circularity.
Common practices	Widely adopted methods that many companies implement due to their familiarity and proven adequacy. While these practices ensure basic compliance with existing circular economy principles, they might not push the boundaries toward significant innovation or improvement. The risks associated with these practices are low, and the results are generally reliable but limited in scope.
Poor practices	Outdated or inefficient approaches that lead to ineffective recycling, reuse, or recovery of materials. These practices hinder the circularity potential of products and are detrimental to both environmental goals and business efficiency. They carry high or unintended risks and often result in negative outcomes, such as increased waste, higher lifecycle costs, and potential non-compliance with regulatory standards.

Linking maturity levels to desired outcomes in design for circularity helps organizations strategically enhance sustainability and efficiency. By evaluating practices through these maturity levels, companies can identify how their design strategies align with circular economy goals like waste reduction and resource efficiency. For instance, leading practices might drive innovations in material reuse, while best practices ensure reliable outcomes that support sustainable growth. This approach allows organizations to develop focused improvement plans, effectively allocate resources, and accelerate their transition towards a more sustainable business model. The following sections provide examples of these practices for each of the desired outcomes listed in Section 2.1, illustrating how varying maturity levels can impact the implementation and success of circular design initiatives.

2.2.1. Design strategies for circular outcomes

Desired outcome 1: *Products are designed with features such as reuse, modularity, durability, safety and ease of disassembly which facilitate their integration into circular pathways.*

Level	Practice
Leading	**Modular design innovation:** Introduce cutting-edge modular design technologies that allow consumers to upgrade individual components of a product (such as electronics or vehicles) rather than replacing the entire product. This practice alters consumer habits and industry standards by extending the product's lifecycle and reducing waste.
	Advanced materials research: Develop and use new, high-performance materials that are designed to be fully recoverable without compromising the product’s durability. These materials set new benchmarks in sustainability and performance metrics
Better	**Standardized component designs:** Implement standardized components across multiple product lines to ensure high compatibility and interchangeability, facilitating easier repairs and upgrades. This practice is supported by solid data showing reduced waste and cost savings.
	Design for disassembly: Employ design strategies that enable easy disassembly of products at the end of their lifecycle, using common tools and without damaging the components, making recycling more straightforward and efficient.
Common	**Use of recyclable materials:** Regularly incorporate widely accepted recyclable materials into product designs, which many companies adopt to meet minimum regulatory standards and consumer expectations.
	Durability standards: Apply industry-standard durability tests to ensure products meet a basic level of longevity, which is a well-established method to ensure consumer satisfaction and adequate lifecycle performance.
Poor	**Non-standard, proprietary components:** Design products that require specialized tools for disassembly, which discourages recycling and repair. This approach can often lead to increased waste as consumers may find it easier to discard rather than repair or upgrade products.
	Use of mixed materials that complicate recycling: Integrate materials that are difficult to separate or recycle together, such as certain plastics with metals, which can degrade the quality of recycled materials and increase the complexity and cost of the recycling process.

Desired outcome 2: *Appropriate circular pathways are determined for materials once products reach the end of their current use ensuring seamless transition into new life cycles.*

Level	Practice
Leading	**Lifecycle partnership programs:** Establish collaborative partnerships across the supply chain, including suppliers, manufacturers, and recyclers, to create closed-loop system. These programs often leverage blockchain or other advanced tracking technologies to ensure material traceability and integrity.
	Innovative material recovery techniques: Develop and implement groundbreaking material recovery technologies that can efficiently separate and purify materials at a molecular level, significantly improving the quality and efficiency of recycled materials and setting new industry benchmarks.
Better	**Take-back schemes:** Implement take-back programs that encourage consumers to return products at the end of their lifecycle. These programs are supported by logistic networks that ensure returned materials are efficiently processed and reintegrated into new production cycles.
	Standardized labelling for disassembly: Use clear, standardized labelling on products to indicate how materials can be separated and recycled, supported by detailed disassembly guides.
Common	**Scheduled maintenance services:** Implement routine maintenance services for products, which help extend their usability and efficiency. These services are widespread across various industries, providing a fundamental level of waste reduction by maintaining product functionality longer than might otherwise be the case without such care.
	End-of-Life disposal contracts: Contract with third-party waste management companies to handle end-of-life product disposal. While this practice is common and ensures compliance with regulations, it often focuses more on disposal rather than material recovery and reuse.
Poor	**Lack of End-of-Life planning:** Design products without considering how they will be disposed of or recycled, leading to increased environmental impact and costs associated with waste management. This approach can result in materials being sent to landfills or incinerated rather than recycled.
	Mixed material use: Use designs that incorporate inseparable mixed materials, making it challenging to recycle components effectively. Such practices lead to lower reprocessing value and often force materials to be downcycled or disposed of, rather than reused in their original form or upcycled.

2.2.2. Material dynamics for circularity

Desired outcome 3: *By using recycled or renewable materials entities contribute to a stronger market demand for such materials helping to close the loop and minimize the negative impacts of virgin material use.*

Level	Practice
Leading	**Advanced material substitution initiatives:** Develop and implement innovative material science strategies that create high-performance recycled and renewable materials, which can directly substitute for virgin materials in applications. These initiatives involve cross-industry collaborations and significant R&D investments.
	Circular supply chain integration: Establish fully integrated supply chains that prioritize the use of appropriate quality recycled and renewable materials across all stages of production and manufacturing. To ensure a steady supply of high-quality recycled materials, this may include supplier contracts and advanced logistics, while recognising that the global and local supply of such materials (and its availability to certain consuming segments) is likely to be constrained until late in the 21st century.
Better	**Certified recycled content:** Use materials that are certified for their recycled content by reputable third-party organizations. This practice ensures transparency and reliability in the amount of recycled content claimed, building trust with consumers and stakeholders.
	Closed-Loop recycling partnerships: Establish partnerships with aluminium end-users and recycling facilities to create closed-loop recycling systems. These partnerships ensure that aluminium waste from products is directly returned, reprocessed, and reused in new products.
Common	**Recycling programs:** Participate in industry-standard recycling programs that focus on commonly recycled materials like paper, glass, and certain plastics. While these programs help reduce waste, they often don't significantly impact the broader use of virgin materials in other areas.
	Use of some recycled materials: Incorporate recycled materials in non-critical parts of a product or in packaging rather than in the main product itself, which can be a more cautious approach that companies take without fully committing to recycled materials.
Poor	**Inconsistent use of recycled materials:** Sporadically use recycled materials without a clear strategy or commitment, leading to inconsistent product quality and reliability, which can undermine consumer confidence and do little to promote the broader use of recycled materials.
	Low-quality materials: Use recycled materials of poor quality that may compromise product performance or durability, ultimately discouraging consumers from choosing products made from recycled materials and damaging the reputation of recycled products.

Desired outcome 4: *Materials that are likely to retain value through multiple cycles are prioritized, enhancing the overall sustainability of the products.*

Level	Practice
Leading	**Material innovation labs:** Develop specialized labs focused on material innovation where new composite materials are engineered to maximize lifecycle value. These labs not only focus on the immediate recyclability but also on the durability and functionality of materials in multiple cycles, setting new standards in material science.
	Cross-industry collaboration for material reuse: Engage in partnerships across different industries to facilitate the reuse of materials in various contexts. For example, materials used in the automotive industry could be designed for subsequent use in the construction industry, thereby extending the material's lifecycle and its economic value.
Better	**High-quality material sourcing:** Implement strict sourcing guidelines to ensure that only high-quality, durable materials are used in production. These materials are chosen for their proven ability to withstand multiple recycling processes without significant degradation.
	Lifecycle assessment tools: Regularly employ comprehensive lifecycle assessment (LCA) tools to evaluate the long-term value of materials used in products, ensuring that only those with the highest potential for reuse and recycling are selected while also minimize environmental impacts across various categories (e.g. global warming potential).
Common	**Standard recycling materials:** Use commonly recycled materials such as aluminium. These materials are well-understood and widely accepted in recycling streams but may not always be optimized for multiple reuse cycles in terms of retaining high value.
	Regular material reviews: Conduct periodic reviews of material choices based on cost and basic environmental standards. While this practice helps maintain a baseline for sustainability, it may not aggressively enhance the material's value retention through multiple cycles.
Poor	**Use of non-durable, single-use materials:** Persist in using cheap, non-durable materials designed for single use without consideration for future reuse or recycling. Such practices are short-sighted and lead to increased waste and reduced sustainability.
	Lack of upfront material evaluation: Fail to evaluate materials for their long-term reuse and recycling potential before incorporating them into products. This oversight can result in the selection of materials that become contaminants in the recycling stream, undermining the sustainability of the products.

2.2.3. Knowledge and information sharing

Desired outcome 5: Entities gain a comprehensive understanding of the circular potential of their products across all levels of the organization, identifying both opportunities and solutions to enhance the cycling of resources.

Level	Practice
Leading	**Integrated circular design training:** Implement comprehensive training programs that not only focus on design principles but also integrate circular economy concepts into every stage of product development. Hands-on workshops with circular economy experts and real-world project applications help innovate and optimise product life cycles.
	Advanced analytics and simulation tools: Utilize cutting-edge analytical tools and simulations to model the lifecycle of products and their components. These tools help predict long-term impacts and identify potential improvements in the design phase, allowing companies to innovate and lead in circularity practices effectively.
Better	**Regular sustainability audits:** Conduct regular sustainability audits that assess the environmental impact and resource efficiency of products throughout their lifecycle. These audits help identify areas for improvement and ensure that circular economy principles are being effectively integrated into product designs.
	Cross-departmental circular economy committees: Establish cross-departmental committees to foster a broader understanding of circularity within the organization. These committees are responsible for sharing insights, discussing challenges, and spearheading initiatives that promote resource cycling.
Common	**Employee sustainability workshops:** Hold regular workshops and training sessions for employees to raise awareness about the circular economy and its benefits. While these sessions provide a basic understanding, they may not always be deeply integrated into practical job functions or design processes.
	Participation in industry sustainability programs: Engage in industry-wide sustainability programs or partnerships, such as ASI. These programs provide frameworks and guidelines for implementing circular practices but may lack customization to the specific needs and potential of individual companies.
Poor	**Infrequent or superficial training:** Provide only infrequent or superficial training on sustainability and circular economy principles. This approach fails to embed a deep understanding or practical application of these concepts within the company, limiting the potential for innovative solutions.
	Lack of follow-through on circular initiatives: Start initiatives or pilot programs focused on circularity without adequate planning or resource allocation, leading to poor follow-through and limited impact. This practice demonstrates a lack of commitment to genuinely understanding or enhancing the circular potential of products.

Desired outcome 6: Information on how to handle products at the end of their use phase is made available to the public, increasing the likelihood of effective material recovery and recycling.

Level	Practice
Leading	**Interactive digital platforms:** Develop advanced, user-friendly digital platforms that not only provide information on product disassembly but also offer interactive guides, videos, and local recycling options. These platforms can use augmented reality (AR) to demonstrate the disassembly process in a detailed and engaging manner.
	Partnership with circularity apps: Collaborate with mobile applications that guide users on how to reuse, recover, recycle or dispose of products properly. These apps can notify users about the nearest recycling facilities or scheduled waste collection services, tailored to the specific materials and components of the products.
Better	**QR codes on products:** Include QR codes on product labels that, when scanned, direct consumers to a webpage detailing disassembly instruction, local circularity policies, and how to properly dispose of the product to ensure it enters the correct recycling stream.
	Product circularity data sheet implementation: Provide each product with a comprehensive Product Circularity Data Sheet that details the material content, complete disassembly instructions, and clear recycling options.
Common	**Standard recycling labels:** Use standard recycling symbols and brief instructions on product packaging that indicate the recyclability of the product or packaging. While helpful, these labels often provide limited information and rely on the consumer's existing knowledge and local recycling capabilities.
	Company website FAQ: Include a section on the company website dedicated to frequently asked questions about product disposal and recycling. This section provides basic information but may not cover detailed end-of-use handling for all products.
Poor	**Lack of disposal information:** Products are sold without any information on how to properly dispose of them at the end of their use phase. This absence of guidance often leads to improper disposal, with products ending up in landfills instead of being recycled.
	Confusing or misleading information: Provide complex or misleading recycling information that can confuse consumers about how to properly handle the disposal of products. This might include using generic recycling symbols without specific instructions, leading to contamination of recycling streams.

2.2.4. Chemical and material transparency

Desired outcome 7: An increasing percentage of a product's material and chemical composition is disclosed, enhancing the ability to assess potential risks and foster the development of safer chemical handling practices.

Level	Practice
Leading	**Full material disclosure through blockchain technology:** Implement blockchain technology to provide a transparent, tamper-proof record of every material and chemical used in a product. This technology can track the provenance and safety data of materials from the point of origin to the final product, offering unprecedented transparency.
	Integrated Product Passports: Develop digital product passports that detail the full material and chemical composition of products. These passports are accessible to consumers and recyclers alike and are updated in real time as product formulations change, ensuring that all stakeholders have access to the most current data.
Better	**Third-party verified material disclosures:** Engage independent third parties to verify material and chemical disclosures. This practice not only enhances credibility but also ensures that disclosures meet international standards for environmental and health safety.
	Comprehensive Safety Data Sheets (SDS): Provide detailed safety data sheets for products that are readily available to consumers and supply chain partners. These sheets include information on the chemical composition, associated hazards, handling, storage, and emergency measures.
Common	**Standard regulatory compliance:** Comply with existing regulations such as REACH in the European Union or TSCA in the United States by disclosing certain chemical substances used in products. While this practice meets legal requirements, it often covers only specific chemicals of concern and may not provide a complete picture of all materials used.
	Basic product labelling: Include basic material and chemical composition information on product labels or packaging. This approach provides some level of transparency but is often limited to major components or materials that are directly relevant to consumer safety.
Poor	**Selective disclosure:** Only disclose information about non-controversial or non-hazardous materials while omitting details about additives or chemicals that might be perceived as hazardous. This selective transparency (even when pushed by legal requirements) can mislead consumers and hinder risk assessment and safety evaluations.
	Inadequate or outdated information: Provide material and chemical composition information that is vague, inadequate, or not regularly updated. This can lead to misinformation and make it difficult for consumers and regulators to assess potential risks accurately.

Desired outcome 8: Strategies are implemented to reduce the risk associated with the use of hazardous chemicals and emissions in the supply chain, while demonstrating measurable progress in these reductions.

Level	Practice
Leading	**Comprehensive chemical management system**: Implement an advanced chemical management system to ban all known hazardous chemicals in the supply chain. This safety and sustainability system use safer alternatives with supplier collaboration to develop and use safer alternatives, real-time monitoring, and compliance checks.
	Green chemistry innovation: Invest in research and development for green chemistry solutions, which focus on designing chemical products and processes that reduce or eliminate the generation of hazardous substances. This approach not only minimizes risk but also drives innovation within the industry.
Better	**Enhanced supplier certification and training programs:** All suppliers must meet certified environmental standards and participate in ongoing training on new regulations and safer chemical practices. Third-party audits verify these certifications and training, ensuring chemical management best practices.
	Regular chemical audits and adaptive substitution plans: Conduct dynamic supply chain chemical audits with a proactive substitution plan updated with scientific and regulatory changes. Based on risk assessments, this plan proposes safer alternatives and a timeline for phasing out hazardous chemicals.
Common	**Compliance with regulatory standards:** Maintain compliance with governmental regulations that restrict the use of certain hazardous chemicals in products and processes. Ensure that all operations meet at least the minimum legal requirements, which provides basic protection against the most harmful chemicals.
	Chemical safety training: Provide basic training for employees and suppliers on the safe handling and disposal of hazardous chemicals. This training helps manage risks but focuses on handling rather than eliminating hazardous chemicals.
Poor	**Inadequate monitoring and enforcement:** Maintain nominal policies against the use of hazardous chemicals but lack a consistent and effective monitoring system to ensure compliance. This sporadic enforcement often results in the continued use of harmful chemicals
	Lack of transparency in chemical use: Provide little information on hazardous chemical management and phase-out strategies in the supply chain. Lack of clarity can lead to poor accountability and suboptimal decision-making by all stakeholders.

3. Tools to Support Design for Circularity

In the pursuit of sustainable design, various principles and tools have been developed to assist designers and companies in embedding circular economy concepts into their products and processes. These tools not only enhance environmental performance but also improve economic and social outcomes by optimizing resource use and minimizing waste. Here are some key tools that can significantly elevate your design for circularity. These can be grouped into the categories:

- System Thinking,
- Design for X, and
- Metrics/Assessments:

3.1. Circular thinking tools

- Life Cycle Assessment (LCA): This tool evaluates the environmental impacts of a product or process from raw material extraction through to disposal. When combined with Life Cycle Costing and Social LCA, it forms part of a broader Life Cycle Sustainability Assessment, offering a more comprehensive understanding of a product's environmental, economic, and social footprints. This holistic approach is essential for assessing the overall sustainability of products throughout their life cycles.
- 10 R's Hierarchy: A framework encompassing Refuse, Rethink, Redistribute, Reduce, Reuse, Repair, Repurpose, Regenerate, Recycle, Reclaim. It guides designers in choosing strategies that prioritize waste reduction and resource efficiency.
- Resource/Waste Mapping: Identifies and visualizes resource/waste streams within a process or facility to highlight areas where resource efficiency can be improved.
- Closed-Loop Thinking: Encourages the design of systems where resources are continuously circulated within closed loops, minimizing waste and the use of virgin materials.
- Material Flow Analysis: Analyses the movement and use of materials within systems to identify inefficiencies and opportunities for improvements in circularity.
- Systems Thinking: Emphasizes the interconnectedness of elements within a system, promoting holistic problem-solving that encompasses all phases of a product's lifecycle.
- Product Journey Mapping: Visualizes a product's entire lifecycle to identify critical points where improvements in sustainability and circularity can be made.

3.2. Design for X tools

Design for X (DFX) emphasizes creating high-quality, efficient products from the outset, avoiding the need for later modifications. DFX promotes a holistic design approach that considers all product aspects early in the design phase, significantly reducing time and costs associated with modifications. This methodology includes various specializations such as design for manufacturing (DFM), assembly (DFA), and quality (DFQ), each targeting specific improvements in the product development process.

- Design for the Value Chain: Considers the entire supply chain in the design process to create maximum value and minimize negative impacts, ensuring that all aspects of production and distribution are optimized for circularity.

3.3. Monitoring and assessment tools

- Eco-design assessment: An environmental rating that indicates a product's sustainability and circularity, helping consumers and businesses make informed choices.
- Material selection: Categorizes and compares materials based on their properties, environmental impacts, and suitability for circular applications.
- Circular Packaging Assessment: Analyse packaging materials based on their recyclability, reuse potential, and overall circularity, guiding improvements in packaging design.

3.4. Other tools

- Circular Business Canvas: A strategic tool that helps organizations plan their activities with a focus on circular economy principles, aligning business models with sustainable practices.
- Circular Materials Databases: Provide information on innovative materials that are suitable for use in a circular economy, aiding designers in selecting the most appropriate and sustainable materials.

4. Final Remarks

ASI is committed to guiding and supporting the aluminium industry's transition towards greater circularity. For those looking to contribute or enhance their practices, ASI provides numerous ways to get involved. Members can participate in working groups, contribute to standards revisions, and share best practices and innovations that drive the industry forward. Your active participation not only helps shape the future of the industry but also ensures your operations align with global best practices.

We particularly encourage input on circular product design; for example, sharing your experiences and strategies in integrating reused materials, designing for disassembly, or implementing lifecycle assessments. Your feedback will help us to better understand the industry's challenges and opportunities in these areas. By actively engaging with ASI, you contribute to a collective effort that not only aims to improve the industry's environmental footprint but also enhances its overall competitiveness and sustainability.