

More sustainable product design,
repairability, and end-of-life
readiness in Home Appliances



How tesa's Debonding on Demand technologies can support
to align environmental, regulatory, and technical requirements

Executive summary

Home appliance manufacturers are under increasing pressure to embed sustainability across the full product lifecycle – extending well beyond energy efficiency during use – to include design, production, repair, and end-of-life recovery. Circularity is increasingly recognized as a key design principle across the entire product lifecycle that reshapes how products are conceived, built, serviced, and recycled.

This lifecycle perspective translates into four core capability needs: Design freedom and re-designability during the design phase, reworkability during production, repairability during the use phase, and recyclability at the end of life. Some of these drivers originate from sustainability ambitions and OEM circularity targets, others from cost efficiency and process robustness, and increasingly from regulation.

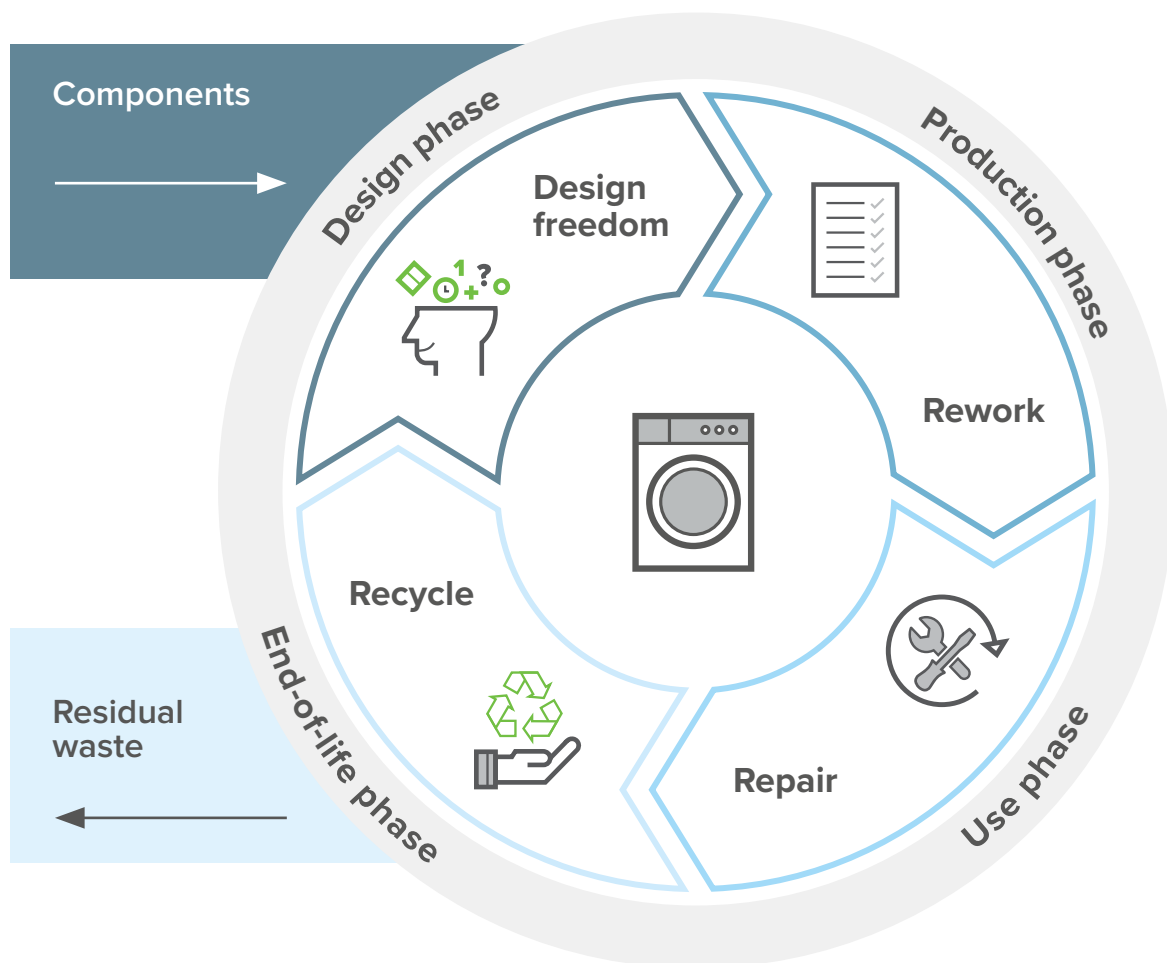
European policy initiatives such as the 'Right to Repair' and the 'EU Battery Regulation' are accelerating this shift, especially in areas related to disassembly, repair access, and battery removability. At the same time, manufacturers must continue to ensure design freedom, production efficiency, and product reliability and durability.

tesa's Debonding on Demand technologies aim to address these challenges by combining strong, reliable bonding performance during use with controlled, damage-free separation when required. In doing so, they enable circular product strategies across design, rework, repair, and recycling – without compromising performance or reliability.

1. Circular product design across the appliance lifecycle

Sustainability in home appliances is increasingly understood as a continuous lifecycle journey rather than a set of isolated measures. It begins during product design, continues through production and use, and culminates in recycling and material recovery at end of life. This perspective shifts the focus towards integrated product strategies that allow appliances to remain functional for as long as possible while ensuring that materials and components can re-enter manufacturing cycles after use.

Across this lifecycle, four capability requirements emerge as central enablers of circularity. Prototypes must be adaptable during development and support for components to come apart by design. Resulting products are reworkable during manufacturing, repairable during use, and recyclable at end of life. These requirements are driven by a combination of sustainability targets, cost and process efficiency considerations, customer expectations, and increasingly by regulatory frameworks.



Flexibility & freedom during the design phase

In the early development phase, re-designability refers to the ability to modify, remove, and replace components without damaging adjacent parts – enabling fast prototyping and iterative design changes while maintaining system integrity. Modern appliance design is characterized by short innovation cycles, platform strategies, and frequent product updates. Bonding technologies must therefore provide strong, reliable integration while still supporting efficient design flexibility and freedom as well as prototype testing.

From a development perspective, re-designability reduces cost and time to market by enabling components to be removed, adjusted, or replaced without damaging surrounding materials. This supports faster validation of new concepts and extends the usable life of design platforms.

Throughout the design phase, engineers can design with the possibility for future component separation in mind, thereby rethinking the entire product lifecycle from assembly to end of life.

Use case: Appliance platforms increasingly rely on frequent updates and product derivatives (e.g. new electronics, sensors, or connectivity modules). Designing subassemblies as modular, replaceable units enables non destructive adjustments during development, ensuring that components can be modified without impacting surrounding parts and allowing platforms to evolve efficiently over time.

Re-workability in the production phase

During manufacturing, re-workability has a direct impact on both sustainability and economic efficiency. In complex appliance assemblies, defects or deviations are unavoidable. If assemblies cannot be separated without damage, even minor issues may lead to the scrapping of high-value components, increasing material consumption and production costs.

Seamless and damage-free disassembly allows manufacturers to correct defects, replace faulty parts, and return assemblies to the production flow. This improves process robustness, reduces scrap rates, and lowers the environmental footprint of manufacturing operations. Re-workability is especially critical for expensive, sensitive, or resource-intensive components, as each avoided scrap cycle saves materials, energy, and time.

Use case: In TV production, re-workability is especially critical due to the high value of modern display technologies such as OLED and advanced LCD panels. After final assembly, TVs undergo quality inspection, and defects, especially due to improper positioning, may require separation of the screen from the housing frame. With conventional permanent bonding, this step is often destructive, leading to the scrapping of otherwise functional displays. Debondable tapes enable non destructive separation and reassembly, allowing faulty components to be corrected without damaging the display. This reduces scrap, improves production yield, and significantly lowers cost and environmental impact in the manufacturing of high-value TVs.

Repairability in the use phase

Repairability is evolving from a differentiating feature into a baseline expectation. Consumers increasingly expect appliances to be repairable, and OEMs are embedding product longevity into their sustainability strategies. At the same time, regulatory initiatives such as 'Right to Repair' are raising formal requirements for disassembly, access to components, and the availability of spare parts beyond authorized service networks.

In practical terms, repairability requires that key components such as displays, control units, or batteries can be replaced without destroying surrounding structures. Permanent bonding solutions create barriers to repair, increase service complexity, and shorten product lifetimes. In contrast, architecture designed for controlled disassembly enables component replacement and upgrades, extending product use, and reducing waste.

Repairability assessment schemes, such as repairability indices, further reinforce this trend by making ease of repair and component accessibility transparent and comparable. As a result, repairability must be considered from the earliest design stages. This includes the use of modular, easily replaceable components as well as the careful selection of suitable bonding and debonding technologies.

Use case: In high usage appliances with integrated displays or HMI panels, failures can occur during the use phase due to electronics issues or accidental damage. With conventional permanent bonding, replacing the display often damages surrounding components or the front panel. Enabling damage-free removal and replacement of displays during lifecycle, can allow targeted repair instead of scrapping large functional appliances. This supports longer product lifetimes and reduces service costs.

Recyclability at end of life

At the end of a product's life, recyclability largely depends on how effectively materials and assemblies can be separated. Clean separation improves recycling yields, increases material purity, and enables the recovery of valuable raw materials or functional components.

Bonding technologies play a decisive role at this stage. Assemblies that can be dismantled in a controlled manner support efficient recycling processes and help reduce contamination of material streams. Regulatory pressure further reinforces this requirement: Rules that mandate easier disassembly for repair or battery access also shape end of life dismantling pathways. As a result, disassembly must be treated as a design feature rather than an afterthought, serving both repair and recycling objectives.

Use case: Modern kitchen designs provide a good example. Minimalistic aesthetics with sleek glass fronts are popular because they are robust, durable, and easy to clean. Today, such designs are typically achieved by bonding glass components using adhesive solutions such as acrylic foam tapes or liquid adhesives. However, when it comes to recycling, both approaches hinder clean and easy separation.

A debondable adhesive solution can address this challenge by enabling controlled separation of bonded components through a defined trigger. No re-design introducing screws and bolts is needed, which could harm the sleek designs and inherently damage materials by requiring holes. This allows parts to be detached when required, supporting repair, refurbishment, and efficient recycling at the product's end of life. These lifecycle requirements place new demands on bonding technologies that conventional solutions cannot fully meet.

2. Technology challenge: From permanent bonding to controlled separation

Across all lifecycle phases, bonding technologies sit at the intersection of product performance, manufacturability, and circularity. They must ensure reliable bonding under thermal, mechanical, chemical, and environmental stress while not preventing design freedom, rework, repair, or end-of-life separation. Conventional bonding approaches sometimes require trade-offs between these requirements.

Mechanical fastening methods such as screws offer reversibility and standardization, but they introduce visible fastening elements, require additional space, concentrate loads at discrete points which can cause material breakage, and increase part count and assembly time. These characteristics conflict with current appliance design trends toward thinner constructions, seamless surfaces, and efficient automated production.

Conventional adhesive tapes, in contrast, enable invisible, full-surface bonding with high design freedom. They distribute loads evenly, support multifunctionality such as damping and sealing, and are well suited for automation. However, traditional adhesive bonds are often effectively permanent. Removal typically requires destructive methods that damage substrates and prevent reuse or clean recycling. As a result, conventional adhesive solutions support performance and manufacturability but can obstruct circularity requirements if not designed for controlled reversibility.

3. tesa's Debonding on Demand technologies: Controlled separation without compromise

tesa's Debonding on Demand technologies aim to address the challenges of permanent bonding in modern appliance design. They can combine strong, reliable bonding performance during use with targeted, non destructive separation when required. The key differentiator is control: Debonding is activated intentionally through defined mechanisms, rather than through excessive force or destructive methods.

During use, tesa's Debonding on Demand technologies can support solutions to perform like conventional high performance adhesive tapes – providing durability, sealing, and environmental resistance – while enabling controlled, non destructive disassembly when redesign, rework, repair, or recycling is required.

Depending on the design and application, different release mechanisms can be applied, including:

- Stretching & debonding
- Thermal debonding
- Electrical debonding
- Laser debonding

Together with our customers, our Application Solution Engineering team works closely to evaluate the specific application, process conditions, and lifecycle requirements. Based on these factors, the team tailors and recommends the most appropriate Debonding on Demand release mechanism – ensuring reliable performance during use while enabling controlled disassembly when required across development, production, repair, or end of life scenarios.

Across the appliance lifecycle, tesa's Debonding on Demand technologies can support circularity in a practical and application oriented way. During development, they can enable rapid assembly and disassembly cycles without damaging components, supporting faster iteration and reuse of parts. In production, non destructive rework reduces scrap, improves yield, and lowers material consumption by allowing high value assemblies to be corrected rather than discarded.

During the use phase, tesa's Debonding on Demand technologies enable the replacement of defective components and support repair instead of full product replacement, aligning with regulatory requirements for non destructive disassembly and improved repair access. At end of life, controlled debonding enables clean material separation and higher quality recycling, improving material recovery and supporting circular economy objectives.

4. Conclusion

The transition toward more sustainable home appliances is driven by a combination of circularity goals, cost and process efficiency requirements, customer expectations for longer product lifetimes, and increasingly stringent regulatory frameworks. In this environment, joining technologies become a strategic design decision rather than a purely technical detail.

Conventional bonding methods often force compromises between performance, design freedom, and reversibility. tesa's Debonding on Demand technologies can enable future-ready alternatives by combining reliable bonding

during use with controlled, non destructive disassembly when required. By enabling design freedom and redesign, rework, repair, and high-quality recycling without compromising performance or manufacturability, tesa's Debonding on Demand technologies aim to support circular product strategies across the entire appliance life-cycle.

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Bond with confidence. Release with control.

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