

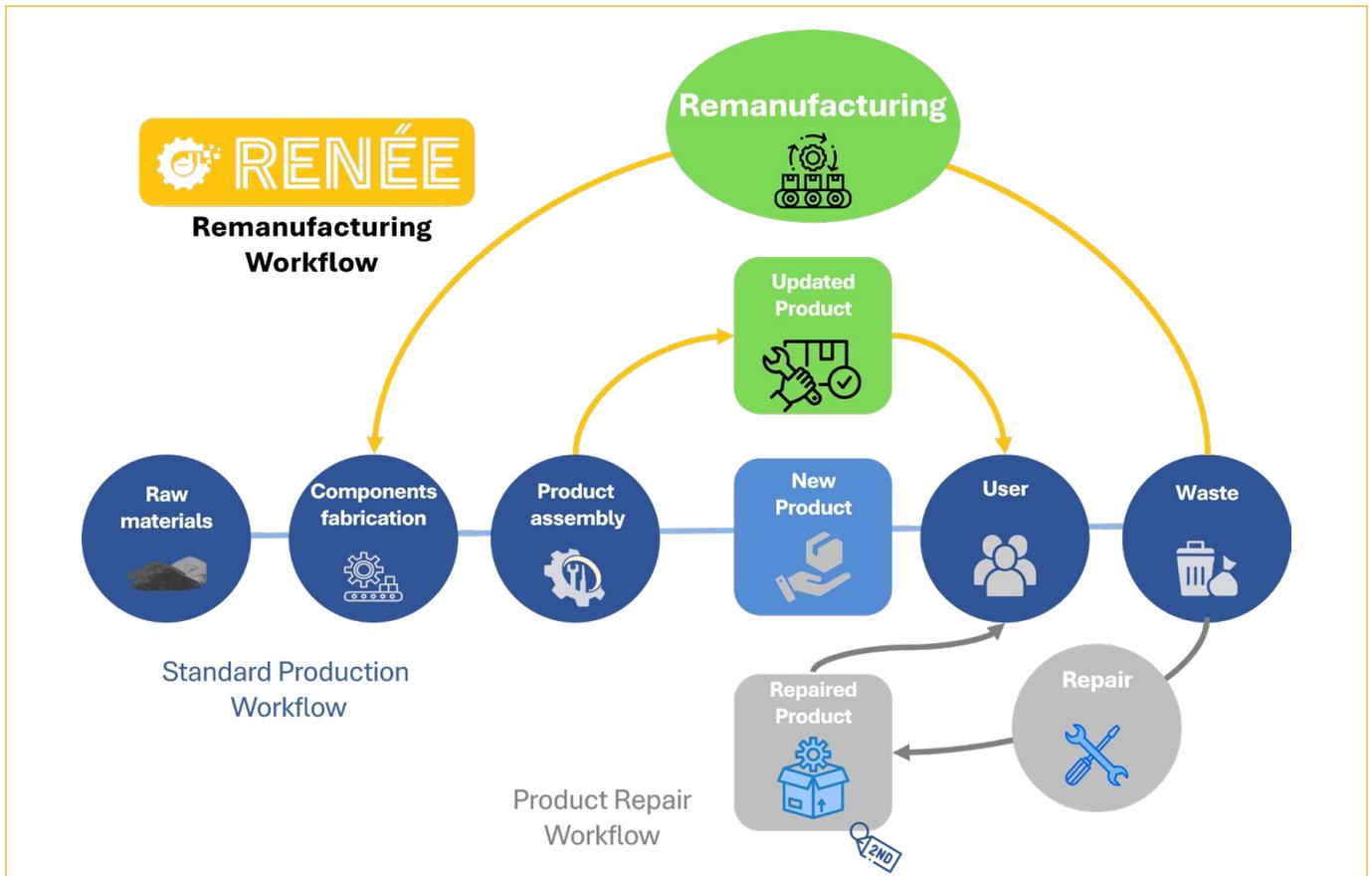
FLEXIBLE ReMANUFACTURING

using AI and Advanced Robotics
for Circular Value Chains
in EU Industry



Across Europe, manufacturing fuels prosperity and innovation. It generates jobs, strengthens competitiveness, and delivers the technologies that drive modern life. Yet, this strength comes with a challenge: industries remain resource-intensive, consuming raw materials and energy at unsustainable rates while producing significant waste. In an era marked by climate change, supply chain disruptions, and critical raw material shortages, one principle stands out as both a necessity and an opportunity — **remanufacturing**.

Remanufacturing is more than repair or recycling. It is a process of restoring used products and components to a “like-new” condition, ensuring performance, quality, and reliability comparable to new products. By doing so, it not only conserves resources and reduces emissions but also unlocks new business models and consumer value. In fact, remanufacturing lies at the heart of the circular economy, where value is retained and extended rather than discarded.



▲ Figure 1. Remanufacturing Workflow (Source: [1])

Remanufacturing Challenges

Despite its promise, remanufacturing is not yet a mainstream practice. Uncertainty about the condition of returned products, variability in supply and demand, and the lack of standardized processes all present barriers. Inconsistent quality checks and reliance on manual operations often result in inefficiency and higher costs.

Moreover, industries face the task of ensuring that remanufactured goods meet the same safety and performance standards as new ones, a challenge that demands innovation in technology, operations, and educated operators.

Promoted Content

The [RENÉE](#) EU-funded project (GA 101138415), funded by the European Union's Horizon Europe research and

innovation programme, is driving the adoption of circular economy principles through innovative remanufacturing solutions. Manufacturing remains a cornerstone of European economic growth, yet it is also a significant consumer of resources and energy. RENÉE aims to transform this landscape by addressing key challenges in remanufacturing, including resource scarcity, environmental impact, and variability in returned products.

“RENÉE aims to transform this landscape by addressing key challenges in remanufacturing, including resource scarcity, environmental impact, and variability in returned products.”

Lessons from RENÉE's Industrial Use Cases

Recent pilot initiatives across Europe demonstrate how these challenges can be transformed into opportunities:

E-Mobility Motors



In France, remanufacturing of electric vehicle motors enables valuable rare earth materials to be reused. AI-driven testing identifies which components can be saved, while collaborative robotics support disassembly. The result is a cost-effective, lower-emission alternative to producing new motors.

For workers, ergonomic risks are reduced through robotic assistance, turning physically demanding jobs into safer, technology-supported tasks.



Industrial Robots

In Italy, remanufacturing of industrial robots cuts costs by up to 40% while saving hundreds of kilograms of steel and aluminum. By creating digital twins of the remanufacturing process, operators gain real-time insights, while businesses can adopt new models such as "robot-as-a-service".

These examples illustrate that remanufacturing is not confined to one sector, it is adaptable, scalable, and directly connected to the daily products that shape our lives.

Human Centric Remanufacturing

Remanufacturing is not only about machines. It is also about people. New processes demand new skills, from working with AI-driven diagnostics to operating advanced robotic systems. Workforce development, therefore, becomes critical. Tailored education platforms and operator support technologies ensure that workers are not left behind but instead are empowered by innovation. In this sense, remanufacturing strengthens both environmental and social sustainability.

Household Appliances

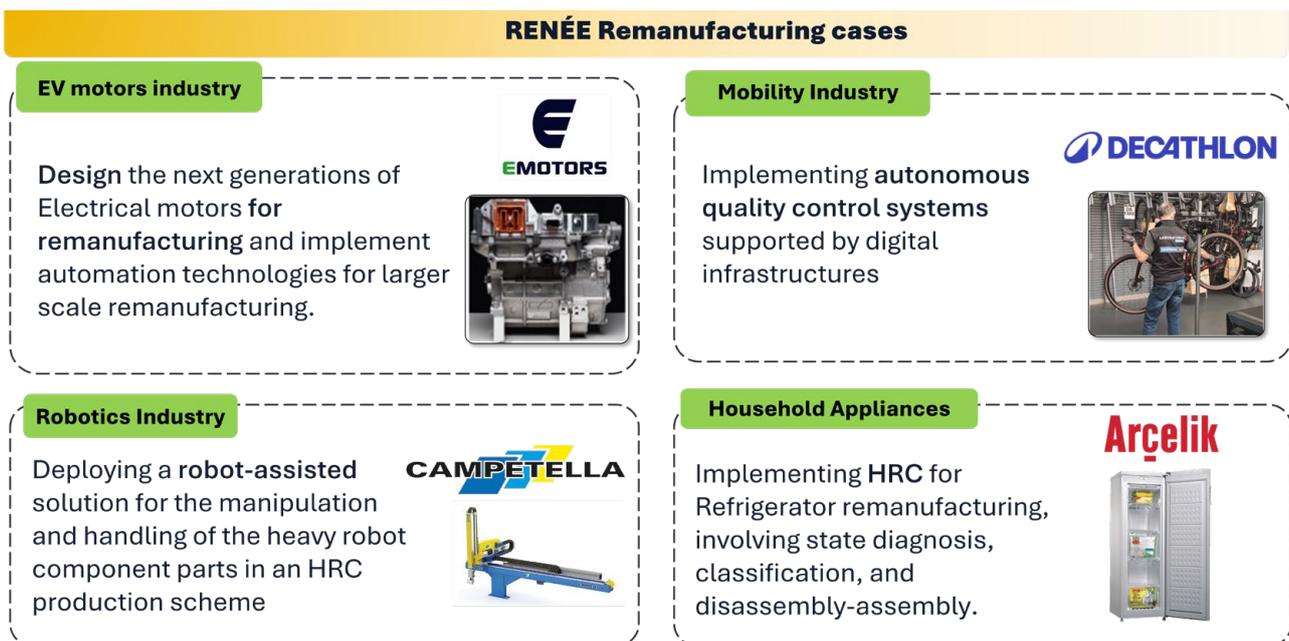


In Türkiye, a major appliance manufacturer is pioneering remanufacturing of refrigerators. Returned units are systematically refurbished, saving nearly 280 kg of CO₂ per unit compared to new production.

Bicycles for Circular Mobility



In collaboration with retail stores, automated systems evaluate and remanufacture used bicycles. The result is affordable, certified second-life mobility solutions, contributing to sustainable transport and reducing raw material needs.



▲ Figure 2. Remanufacturing Use Cases (Source: [2])

“In the coming years, remanufacturing will not only shape how we produce and consume but also how we work and live.”

Looking Ahead

What does the future hold for remanufacturing in Europe?



Digital Integration: Tools such as Digital Product Passports (DPP) will enable full traceability of products across their lifecycle, ensuring that materials and components are easier to reuse and recover.



Generative AI in Industry: Adaptive AI will make it possible to design remanufacturing strategies on the fly, coping with the uncertainty and variability of returned goods.



New Business Models: From leasing to “product-as-a-service,” remanufacturing will support more flexible ownership models, offering consumers affordable and sustainable choices.



Policy Alignment: With the Critical Raw Materials Act, and Circular Economy Action Plan, remanufacturing is gaining political and regulatory momentum. This creates a unique

window of opportunity for industries to align innovation with policy support.

Conclusion

Remanufacturing demonstrates that industry and sustainability can go hand in hand. By extending lifecycles, reducing waste, and rethinking value chains, it contributes directly to Europe’s journey toward climate neutrality. The examples from electric motors, refrigerators, robots, and bicycles show what is possible when technology, business, and people come together. In the coming years, remanufacturing will not only shape how we produce and consume but also how we work and live. It is a powerful reminder that the future of industry lies not in producing more, but in producing better — for people, for business, and for the planet. ■

Authors:



References

[1] <https://renee-project.eu/>

[2] <https://www.effra.eu/news/renee-advancing-flexible-human-centric-remanufacturing/>