

DTU reManuFactory

COMPETITIVE REMANUFACTURING PROCESSES

HOW CAN COMPANIES EFFICIENTLY CLEAN, DISASSEMBLE, INSPECT AND REASSEMBLE PRODUCTS?

Whether you are a small or large company, the National Centre for Remanufacturing, reManuFactory, can support the development and operation of competitive remanufacturing processes.

The Danish national knowledge and competence centre for remanufacturing, reManuFactory, based at the Technical University of Denmark (DTU), helps Danish manufacturing companies transform worn products into new business opportunities. The centre addresses industrial companies in Denmark that develop and manufacture advanced, technology-intensive products involving multiple materials and technologies – products that often hold significant but underutilised potential for remanufacturing. reManuFactory consists of several research units, each with its own dedicated focus area within remanufacturing.

This research unit focuses on addressing key challenges faced by Danish industry in establishing effective remanufacturing systems. This unit supports the development of competitive processes across the full remanufacturing chain, including inspection, disassembly, cleaning, repair, and reassembly.

WHAT WILL YOU GAIN FROM THE COLLABORATION?

Your company will receive hands-on support in developing and optimising remanufacturing processes across all critical stages. This includes access to validated methodologies for non-destructive inspection of returned products, components, and materials, as well as tools for contamination assessment and cleaning to ensure stable performance and reliability.

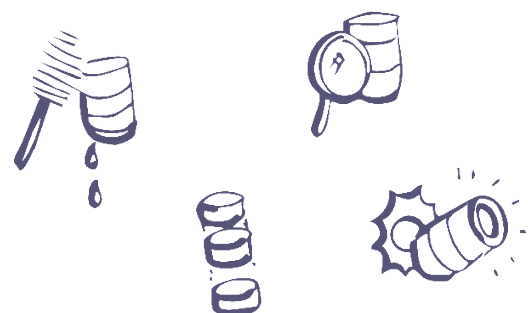
You will gain access to advanced process chains for component repair, including additive manufacturing technologies, and methods for efficient disassembly, repair, and material recovery.

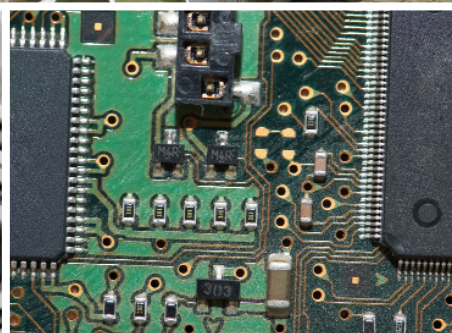
In addition, you will have the opportunity to engage with a flexible remanufacturing robot cell demonstrator, enabling testing of automated inspection, disassembly, repair (e.g. via *Direct Energy*

Deposition and machining), reassembly and quality assurance in an industrially relevant setup.

BENEFITS OF PARTICIPATION

- Develop remanufacturing processes based on cross-disciplinary integration of materials science, production technology, systems engineering, and design.
- Gain access to more affordable and sustainable repair for worn components, reducing downtime and maintenance costs.
- Enable repair rather than replacement of components, lowering CO₂ footprint, and opportunities to offer service solutions based on repair and refurbishment.
- Achieve effective value recovery of materials and components.
- Gain access to validated methodologies, tools, and process chains developed within the project.
- Gain the opportunity to test remanufacturing approaches on your own products through DTU courses (with participation from both undergraduate and master's students).





INPUT FROM YOUR COMPANY

- Returned parts, data sheets, performance specifications, and restrictions.
- Active participation in testing and validation of remanufacturing process chains.
- Time commitment: approximately 50-100 hours.

HOW DO WE WORK?

The collaboration is structured as a hands-on process where your company works closely with researchers to test, validate, and optimise remanufacturing process chains. This includes practical experimentation, data-driven evaluation, and iterative improvement of processes across inspection, repair, and reassembly stages.

The process is structured into four interconnected phases, each with clear activities, outputs, and touchpoints between your company and the research team:

1. *Scoping and diagnostic phase.* Understand your products, challenges, and opportunities and get a shared definition of the most promising remanufacturing scenarios and a tailored plan for testing and validation.
2. *Technology exploration and experimental setup.* Design and prepare experiments that address your specific industrial needs and get experimental plans and initial configuration of candidate remanufacturing process chains.
3. *Hands-on experimentation, testing and data-driven evaluation.* Validate, compare, and refine remanufacturing processes under realistic conditions and get validated findings, quantified performance metrics, and evidence-based selection of the most competitive process chains.

4. *Process optimisation and industrial integration.* Translate validated solutions into robust, scalable processes fit for industrial adoption and get a well-defined remanufacturing process chain ready for transfer to industrial implementation, accompanied by recommendations for scaling and next development steps.

ABOUT THIS RESEARCH UNIT

The research unit enables the development and operation of competitive remanufacturing processes through the integration of materials science, production technology, systems engineering and design. The work is structured around four main streams:

- Development of advanced inspection techniques for characterisation of parts, components and materials.
- Establishment of validated process chains for remanufacturing and repair, including additive manufacturing.
- Development of techniques for effective value recovery of materials and components, including disassembly, sorting, and cleaning.
- Remanufacturing process planning, optimisation and digitalisation, including the use of digital twins.

The unit delivers validated methodologies, process chains, and a flexible robot cell demonstrator to support industrial implementation. These outputs provide a strong, research-based foundation for developing efficient, scalable, and sustainable remanufacturing processes.



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EFFECTIVE TAKE-BACK SYSTEMS

HOW CAN YOU DESIGN STRONG AND RELIABLE RETURN FLOWS FOR REMANUFACTURING?

Whether you are a small or large industrial company, the National Centre for Remanufacturing, reManuFactory, can support you in designing and establishing reverse logistics strategies across the value chain.

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Effective take-back systems are a prerequisite for any form of remanufacturing – but they can be complex to design. *This research unit* focuses on how to design and implement effective take-back systems while considering product characteristics, waste legislation and remanufacturing drivers.

WHAT WILL YOU GAIN FROM THE COLLABORATION?

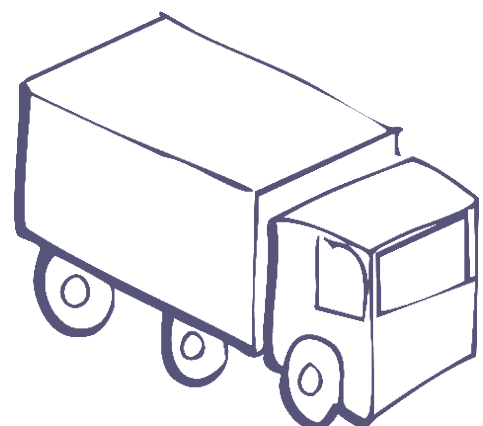
You will gain support in designing more efficient and predictable return flows for remanufacturing – helping to reduce costs, minimise uncertainty and enable scaling – through the use of a configuration tool. Your company will receive guidance in designing stakeholder networks, logistic channels and collaboration strategies across the value chain – from supplier to customer.

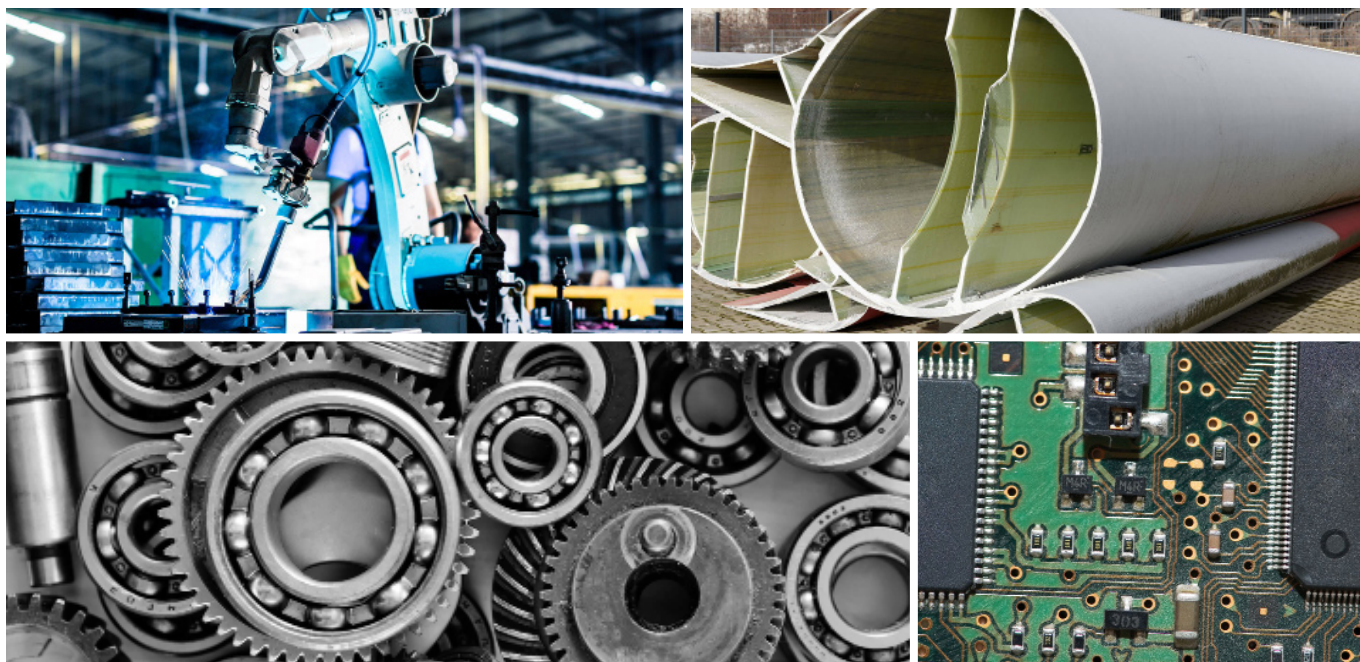
The configuration tool will additionally work with digital technologies integration (e.g., IoT blockchain and sensors) to enhance traceability, efficiency, and transparency. You will also receive support in addressing consumer behaviour through the design

and implementation of engagement strategies, including incentive programmes that encourage product returns at end of life.

BENEFITS OF PARTICIPATION

- Obtain a well-designed takeback solution that integrates consumer engagement strategies and digital technology.
- Develop and strengthen networks among manufacturers, service partners, logistics actors and customers.
- Ensure compliance with relevant waste legislation and environmental regulations.
- Gain direct access to tools and methods developed within the project.





- Gain the opportunity to test remanufacturing approaches on your own products through DTU courses (with participation from both undergraduate and master's students).

INPUT FROM YOUR COMPANY

- Product lifecycle data, consumer behaviour insights, and logistics data.
- Time commitment: approximately 50 hours.

HOW WE WORK?

Your company will be guided through a web-based tool that supports configuration, planning and implementation of take-back systems. You will receive hands-on support in designing stakeholder networks, logistic channels, and collaboration strategies.

- The configuration tool is applied to your company's current situation - whether a take-back system is already in place or not - to get an understanding of your knowledge and capabilities regarding take-back systems.
- You will get a clear understanding of your potential knowledge gaps within take-back operations.
- You are supported in the iterative process of designing and planning a complete and efficient take-back system.

ABOUT THIS RESEARCH UNIT

The research unit develops a user-friendly, open access web-based configuration tool tailored to remanufacturing. The tool is built on benchmarking and analysis of industry best practices, as well as successful examples from multiple sectors and countries. This ensures that the tool is both relevant and well documented, providing a strong research-based foundation for developing effective take-back systems for remanufacturing.



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DESIGN FOR DISASSEMBLY AND CIRCULARITY

HOW CAN PRODUCT DESIGN ENABLE MORE EFFICIENT REMANUFACTURING IN THE FUTURE?

Whether you are a small or large industrial company, the National Centre for Remanufacturing, reManuFactory, can support you in designing products and processes that enables remanufacturing.

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Many existing products were not designed to be disassembled efficiently, making repair and refurbishment costly and complex. *This research unit* address this challenge through a dual objective: enabling technical feasible and economical viable semi-automated (hybrid) disassembly processes and promoting *Design for Remanufacturing* guidelines to improve future product designs.

WHAT WILL YOU GAIN FROM THE COLLABORATION?

You will gain access to a planning tool for selective disassembly sequence planning, alongside *Design for Remanufacturing* guidelines that support new and existing products. You will receive support in planning and evaluating disassembly processes across varying end-of-life conditions.

In addition, your company will benefit from structured assessments of returned products, focusing on disassembly, durability and remanufacturing potential. This includes guidance on optimising the disassembly sequence and the appropriate level of

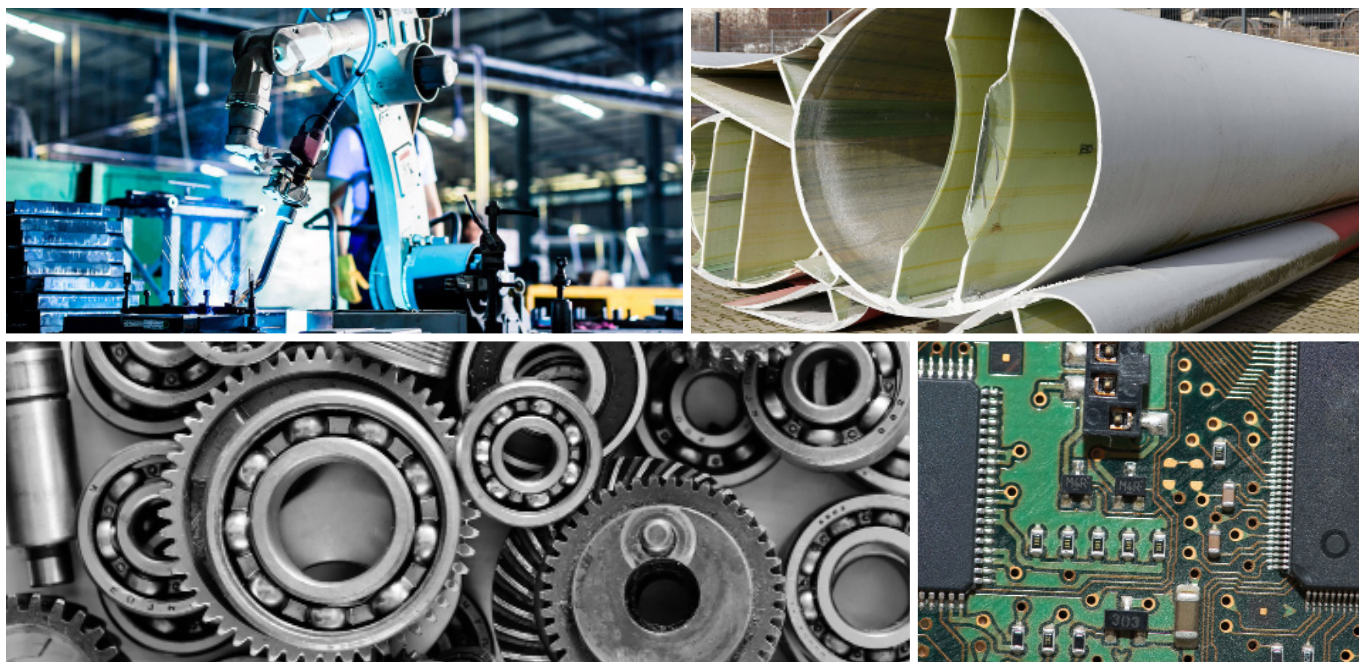
disassembly. These efforts help to improve both efficiency and economic viability.

You will also gain access to advanced methods such as semi-automated disassembly techniques and algorithm-based planning tools that identify optimal disassembly sequences - reducing manual effort, cost and risk of errors.

BENEFITS OF PARTICIPATION

- Achieve more efficient handling of returns and warranty claims, with improved standardisation of service processes and lower cost of remanufacturing of key components.





- Enable faster and more reliable planning of remanufacturing processes through automated disassembly sequencing.
- Reduce errors and operational risks through data-driven and algorithm-supported decision-making.
- Build a foundation for future automation and robot-assisted disassembly.
- Gain direct access to tools and methods developed within the project.
- Gain the opportunity to test remanufacturing approaches on your own products through DTU courses (with participation from both undergraduate and master's students).

INPUT FROM YOUR COMPANY

- Product information data, design specifications, assembly and disassembly process data.
- Returned products and parts, data sheets, performance specifications and restrictions.
- Time commitment: approximately 50-100 hours.

HOW DO WE WORK?

The collaboration follows a structured, hands-on approach through identifying current challenges, defining requirements and limitations, and selecting appropriate methods and tools. Your company will be supported in implementing disassembly

planning methods and *Design for Remanufacturing* guidelines, with continuous feedback and optimisation throughout the process.

ABOUT THE RESEARCH UNIT

This research unit focuses on enabling circular product design and efficient disassembly processes. It combines practical support for disassembly with the development and consolidation of *Design for Remanufacturing* guidelines.

Key activities include:

- Supporting design for disassembly, durability, and robust product architectures.
- Ensuring standardised and consistent disassembly processes across products and use cases.
- Developing methods to ensure robust assemblies and tolerances, enabling seamless integration of new and repaired components.

The unit delivers design guidelines, disassembly planning tools, and structured assessments to support industrial implementation. In addition, algorithm-based tools are developed to automatically determine optimal disassembly sequences, providing a strong, research-based foundation for improving remanufacturability and circular product design.



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COMPETITIVE BUSINESS MODELS

HOW CAN REMANUFACTURING BECOME A VIABLE AND PROFITABLE BUSINESS?

Whether you are a small or large industrial company, the National Centre for Remanufacturing, reManuFactory, can help develop a business model that benefits both the bottom line and the green transition.

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This research unit explores how remanufacturing can become economically attractive, not only technically feasible. The unit focuses on ecosystems, partnerships and value chains within remanufacturing.

WHAT WILL YOU GAIN FROM THE COLLABORATION?

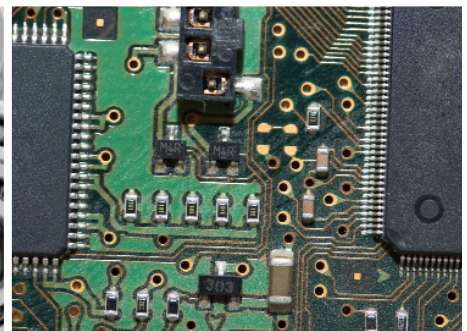
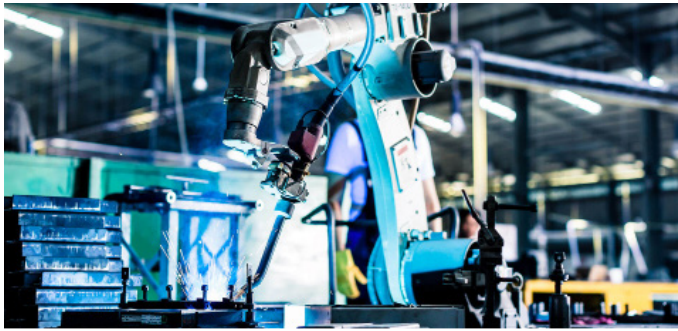
Your company will receive support to experiment with and develop remanufacturing business models with a focus on long-term sustainability and profitability.

You will gain a solid basis for decision-making by assessing how your solution can be scaled, along with proposals for long-term business plans tailored to your company. At the same time, you will receive early estimates of business potential before making major investments, as well as assistance in identifying which products and components are best suited for remanufacturing.

BENEFITS OF PARTICIPATION

- Obtain an early assessment of business model opportunities without the need for major investments.
- Identify new revenue opportunities related to remanufacturing.
- Gain direct access to tools and methods developed in the project.
- Receive plans based on experiments, including business plans and scalability assessments that balance profitability and long-term sustainability.
- Progress from Technology Readiness Level (TRL) 1 to TRL 3 in terms of business model readiness.





- Gain the opportunity to test remanufacturing approaches on your own products through DTU courses (with participation from both undergraduate and master's students).

INPUT FROM YOUR COMPANY

- A description of your current business model (e.g. value proposition, resource use, and energy and material consumption).
- Time commitment: approximately 50 hours.

HOW DO WE WORK?

Your company will be guided through the design, configuration and evaluation of different business model alternatives. Using a set of economic and circularity indicators, your company can make informed decisions and find the right balance between profitability and sustainability.

The project is broadly divided into three phases:

1. Interviews to assess economic and sustainability potential.
2. Conceptualisation of competitive business models.
3. Implementation, measurement and scaling of the developed business models.

ABOUT THIS RESEARCH UNIT

The research unit develops a system that enables companies to effectively conceptualise competitive circular business models specifically aimed at remanufacturing. The system also makes it possible to combine multiple circular strategies - such as refurbishment or repair - to increase the overall circular potential. A central element of the system is the balance between profitability and sustainability.

The development of the system is based on benchmarking and analysis of best practices in industry, as well as successful examples from multiple sectors and countries. This ensures that the tool is both relevant and well documented. The system will therefore provide a research-based foundation for developing competitive business models for remanufacturing.



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PERFORM SUSTAINABILITY SCREENINGS

IS IT SUSTAINABLE TO REMANUFACTURE THE PRODUCT IN QUESTION?

Whether you are a small or large industrial company, the National Centre for Remanufacturing, reManuFactory, can support you with early-stage sustainability screening, without requiring detailed Life Cycle Assessment (LCA) data.

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This research unit develops a practical screening tool that integrates environmental, economic and social aspects into a model tailored for industrial use. The results provide a simple yet robust approach, which supports the comparison of remanufacturing strategies to identify the most suitable option.

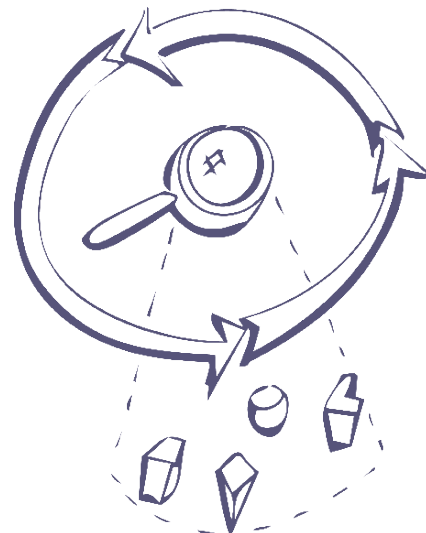
WHAT WILL YOU GAIN FROM THE COLLABORATION?

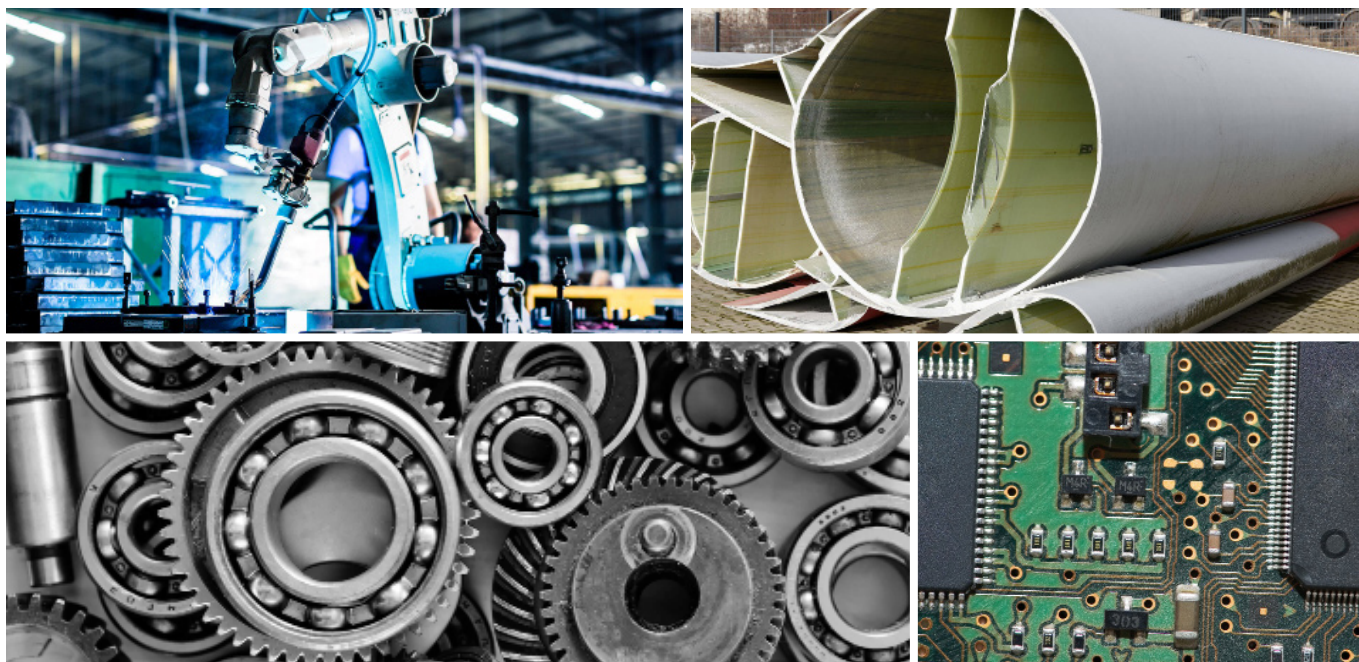
Your company will receive support in screening remanufacturing initiatives to improve sustainability performance while avoiding burden shifting (e.g., reducing emissions one place, but increasing emissions another) and unintended negative impacts (e.g., increased energy consumption due to higher energy efficiency).

You will gain access to a balanced sustainability assessment that integrates robust metrics to accurately evaluate the environmental impact of different strategies. The detailed insights will provide a solid foundation for informed decision-making, enabling improvements in sustainability, operation-efficiency and circularity.

BENEFITS OF PARTICIPATION

- Obtain evaluation and optimisation of the sustainability performance of remanufacturing operations to support sustainable practices.
- Gain direct access to tools and methods developed within the project.
- Gain the opportunity to test remanufacturing approaches on your own products through DTU courses (with participation from both undergraduate and master's students).





INPUT FROM YOUR COMPANY

- Product and process data, including product documentation (e.g. BOM and component structure), return-flow information, and key technical characteristics.
- Environmental, economic, and social data related to current new production (e.g. costs, emissions, and social conditions across the value chain).
- Information on product use and end-of-life management, for both new production and remanufacturing scenarios.
- Organisational and operational insights, relevant to implementing and assessing remanufacturing strategies.
- Time commitment: approximately 50 hours.

HOW DO WE WORK?

Your company will be guided through an interactive, web-based sustainability screening tool to evaluate the sustainability performance of remanufacturing strategies. Further, scenario analyses will be conducted and strategies optimised to maximise sustainability potential.

1. Data collection and input gathering

- Initial interviews to define the remanufacturing strategies to be assessed.
- Possible collaboration/consultation with experts from other research units within reManuFactory to support the identification of relevant indicators.
- Follow-up to guide data and metric collection within the company.

2. Tool application and scenario analysis

- Application of the screening tool based on available data and evaluation of alternative remanufacturing strategies.

3. Results interpretation and implementation support

- Interpretation of results and support in identifying the most suitable strategy.

ABOUT THE RESEARCH UNIT

This research unit develops a screening tool that incorporates sustainability metrics to evaluate various remanufacturing strategies. The objective is to ensure sustainable remanufacturing by assessing environmental, economic and social performance using robust metrics and a structured data collection framework tailored to remanufacturing contexts.



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