De- and Remanufacturing for Manufacturer-centric Circular Economy

Prof. Tullio Tolio
Prof. Marcello Colledani
A new industrial model that decouples revenues from material input, and production from resource consumption is needed for achieving a sustainable development path, both in early-industrialized and in emerging countries.
At technical levels, different business options for Circular Economy have been proposed to generate benefits by exploiting different value-creation mechanisms:

What are the operational implications for manufacturers while introducing these Circular Economy business options?
A new manufacturer-centric Circular Economy model is developed. It grounds on the products, processes and manufacturing systems **Co-evolution framework**.

Manufacturer-centric Circular Economy Model

Business Model

Product

System

- Manufacturing
- De-Reman

Process

Logistics

Global Market
Manufacturer-centric Circular Economy Model

Manufacturer Value-chain and Business Model

Company Knowledge Base

Process

Product

System

Manufacturing

De-Reman

Logistics

Global Market

Pre-use products

Post-use products
Knorr Bremse industrial case

“Premium quality remanufactured products are set to play an even more important part in Knorr-Bremse’s business... And so we are bundling our remanufacturing expertise and increasing our production capacities”. Wolfgang Krinner, Member of the Executive Board.

The current remanufacturing process is carried out in a plant of 9,000 m² for 300 individual product types.

1 - Remanufacturing decisions are taken by the operator (Standard Operations Sheets – SOS)
2 - The disassembly is performed manually.
3 - Cleaning and refurbishing are semi-automated.
4 - The PCB is manually repaired.
5 - All re-assembly operations are performed in the main line (Germany)


Knorr-Bremse invests heavily in remanufacturing business.
A success factor is the capability of exploiting the knowledge about the product materials and critical functional requirements.

The company exploits the synergies between manufacturing and remanufacturing, within the same organization, but in different production sites.

The market is characterized by large variability in the condition of the post-use products. This calls for human-intensive operations in remanufacturing.

Knorr Bremse industrial case
Renault Industrial Case

“Detecting potential resources in end-of-life products and safeguarding their technical and economic value is a new, and virtuous, way of sharpening your competitive edge. Who is better able than the producer of the goods and corresponding services to control these resources, ensure their quality and traceability, and make optimum use of them”. The vision of Jean-Philippe Hermine, Head of the Environmental Plan of the Renault group.

Renault’s plant in Choisy-le-Roi, near Paris, remanufactures automotive engines, transmissions, injection pumps, and other components for resale.

Renaults contributes to the collection and processing of the 25% of the total End-of-Life vehicles (ELVs) in France through Indra, operating a network of 400 dismantlers processing more than 95,000 vehicles in 2015.

Renault, A Committed Player In The Circular Economy, 2014
Renault Industrial Case

The design of Renault vehicles includes constraints linked to dismantling and recycling and considers closed-loop reuse options.

The experts of Indra developed and industrialized advanced engineering applications helping the dismantlers to optimize the disassembly lines.

The joint-ventures with specialized companies are created to implement de-and remanufacturing operations, exploiting the manufacturer product knowledge.

By sharing the transportation among materials having high and low recycling profits, the company improves the overall vehicle recycling rate.

A technological challenge is the development of new dismantling procedures for hybrid and electrical vehicles and the establishment of a proper recovery network for the used batteries.

Joint-ventures with specialized companies are created to implement de-and remanufacturing operations, exploiting the manufacturer product knowledge.
The reported industrial cases support these considerations:

- Circular Economy is already a profitable business opportunity for manufacturers in different sectors.
- The application of Circular Economy businesses is not in contrast but, in fact, is highly synergic with new product manufacturing operations.
- Uncertainties in product returns and market demand are the major causes of complexity in de-and remanufacturing systems, with respect to manufacturing systems.
- Product information plays an important role in the decision making process about de-and remanufacturing operations, and this feature provides competitive advantage to the manufacturer in the implementation of circular businesses.
- The role of advanced de-and remanufacturing technologies and systems is fundamental to achieve the required quality and efficiency of the regeneration process.
- The profitability of the business is strongly influenced by manufacturers’ product design decisions.
- A value-chain and business model reconfiguration may be needed while shifting to new Circular Economy businesses.
## Challenges and requirements for De-and Remanufacturing systems

<table>
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<tr>
<th>Global trends</th>
<th>Challenges and Requirements</th>
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<tr>
<td>Short life cycle of products and high product variety.</td>
<td>Flexibility and reconfigurability.</td>
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<td>High variability in the conditions of post-consumer parts.</td>
<td>Variability of process sequences and processing times.</td>
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<td>Pressure on costs and efficiency.</td>
<td>Need for hybrid automation solutions.</td>
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<td>Poor information about return products.</td>
<td>• Need for ICT solutions and big data management systems.</td>
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<td></td>
<td>• Need for in-line part and materials inspections.</td>
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<td>High fluctuation in materials’ value.</td>
<td>Emphasis on business models, inventory and production planning.</td>
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<td>Increasing product complexity.</td>
<td>• Need for knowledge based tools.</td>
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<td></td>
<td>• Involvement of the manufacturer.</td>
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<td>Increasing quality requirements on recovered components/materials.</td>
<td>Need for automation, repeatability of the processes and quality assurance.</td>
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<td>Increasing attention on safety and ergonomics.</td>
<td>Need for human-centric design of disassembly/sorting workstations.</td>
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Future trends

Crossectorial value chains
  – Example car batteries

Change in business models
  – Example: rented production capacity
Opportunities provided by cross-sectorial Value Chains
The role of batteries in the e-vehicles of the future

- The market of Electric and Hybrid Electric vehicles is constantly growing (EVs and HEVs) ed elettrici (EV). It is forecasted that by 2040 the 35% of the new vehicles sold will be electric.
- In Europe, 200.000 EVs ed HEVs have been sold in 2015, doubling the result of 2014.
The role of batteries in the e-vehicles of the future

**EV TYPES**

1. **Full electric vehicle** (*Tesla*): charge with external energy source, without ICE (internal combustion engine).
2. **Hybrid electric vehicle** HEV (*Toyota*): ICE and electric battery are complementary. Battery charges with kinetic energy during driving.
3. **Plug-in electric vehicle** PHEV (*Chevrolet, Mitsubishi, Honda, BMW*): battery could be recharged both by an external energy source and by energy recovery during driving.

**Function**

<table>
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<tr>
<th>Vehicle category</th>
<th>Micro HEV</th>
<th>Mild HEV</th>
<th>HEV</th>
<th>Plug-in Hybrid</th>
<th>EV</th>
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<tr>
<td>Start / Stop</td>
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<td></td>
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<tr>
<td>Regen. Brake</td>
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<td></td>
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<tr>
<td>Power assist</td>
<td></td>
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<tr>
<td>Electric Drive</td>
<td>+/- 100m</td>
<td>+/- 10km</td>
<td></td>
<td>Up to 200km</td>
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**Electrical specifications**

- Operating Voltage: 12V
- Energy level: 0.3 kWh

Battery technology for vehicle applications
EUROBAT e-mobility Battery R&D Roadmap 2030
CIRC-eV @ Polimi: objectives and vision

Cost structure of conventional ICEVs and EVs. Main differences:
- Battery Pack
- Drivetrain

E-mobility

Characteristics:
- Average life-time 8 years.
- Current cost 150 Euro kWh.
- Residual capacity >80% (24 kWh on average).
- Warranty for manufacturers usually for 5 years (e.g. Tesla, Nissan).

Second-life stationary systems (renewable energy, home, office)
DigiPrime Digital Platform for Cross-Sectorial Value-chains: Project

DIGITAL PLATFORM FOR CIRCULAR ECONOMY IN CROSS-SECTORIAL SUSTAINABLE VALUE NETWORKS

CALL
H2020-DT-ICT-07- 2018-2019
Digital Manufacturing Platforms for Connected Smart Factories

BUDGET
Project costs: 19.257.130,00€
Funding: 15.963.173,50€

DURATION
January 1° 2020 – Dec 31° 2024

OBJECTIVE
To develop a new concept of Circular Economy digital platform overcoming current information asymmetry among value-chain stakeholders, in order to unlock new circular business models based on the data-enhanced recovery and re-use of functions and materials from high value-added post-use products with a cross-sectorial approach.
The overall architecture level of the DigiPrime platform includes:

- A **Multi-node federation structure**, replicable on different existing and additional sectorial platform instances and with easy access for users, which will support the future systematic creation of cross-sectorial circular value-chains.
- A **Semantic data infrastructure**, able to manage and standardize the Babel of information coming from heterogeneous nodes.
- A **Data Policy Framework** to ensure privacy, security, authentication and authorization policies to any information shared among registered users.
DigiPrime Digital Platform for Cross-Sectorial Value-chains: Pilots
Future trends

Crossectorial value chains
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Change in business models
  – Example: rented production capacity
Instead of buying automated assembly facilities the producer rents them from the machine tool builder under the following conditions:

– Assembly systems owned by the financial provider
– Min/max renting time defined in the renting contract.
– Machine tool builder must be able to access the data on the machines
– Maintenance service provided by the machine tool builder
– Rules of system usage included the renting contract
– Interest on the capital paid by the producer and by the machine tool builder
Rented production capacity: Implication for de-remanufacturing

The Machine Tool Builder

- continuously monitor the state of the installed systems;
- knows how to reuse the functions of the modules;
- demanufactures and remanufactures the modules after their use;
- may upgrade the modules at each use;
- Manages the configuration of the system keeping it in line with the real needs;
- facilitates the cross-sectorial usage of the remanufactured modules;
- knows how to reuse materials and avoid environmental risks;
- avoids the use of obsolete unefficient components;
- manages the safety stock modules by bundling uncertainties and limiting the amount of unused capacity;
- It is forced to the design of highly reliable machines and modules with longer lifecycle.
Relevant gaps have to be addressed which constitute future R&D&I priorities in view of the implementation of new manufacturer-centric circular economy businesses.

- Circular Economy Engineering
- Design of circular factories
- Zero-defect de-and remanufacturing
- Automation level in de-and remanufacturing systems
- Adaptable de-and remanufacturing systems
- Digital factory technologies
- Legislation aware de-and remanufacturing design and planning
- New circular business models and value-chains
Conclusions and Prospects

Developing new technologies, systems and strategies for De- and Remanufacturing will bring social benefits worldwide:

- **New jobs** coupled with technological and automation innovations, due to the increased competitiveness for the manufacturers;
- **New efficient and effective technologies and systems** to be exported also to emerging countries;
- **Cheaper products (frugal innovation. e.g. Philips Healthcare)**: it enables manufacturers to offer affordable high-quality products in the emerging global markets.
- **Customers Loyalty** by offering to customers a range of services covering more than just the sale and maintenance phases.
- **Environmental and Energy savings**: raw material extraction is much more demanding from an energy point of view;
- **Robustness** in terms of independency from fluctuations and turbulence in the primary material market (e.g. for rare earths).
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