CarE-Service

Circular Economy Business Models for innovative hybrid and electric mobility through advanced reuse and remanufacturing technologies and services

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Editorial

Welcome to our first newsletter of the CarE-Service project. CarE-Service is a European H2020 project which aims to demonstrated innovative circular business models for electric and hybrid electric vehicles (E&HEVs). Such business models will be based upon new mobility services offered by car-sharing and renting companies. They will allow for the re-use, remanufacturing and recycling of key-components and materials of electric vehicles (EVs) (batteries, metals, and techno-polymers) for applications in the automotive industry as well as other sectors.

With our newsletters we would like to share the latest project advancements in order to build a community of interest in the project that can actively participate in the last demonstration phase and that can evaluate the industrial uptake of final project results. In this first issue we will offer an overview of CarE-Service and its objectives. Moreover, existing solutions and challenges for the circular economy of electric vehicles parts are shortly introduced. Interested? Visit the CarE-Service website and check below linked social media.

Newsletter Contents

CarE-Service in Brief

CarE-Service project is a H2020 large scale demonstration project funded under the agreement No 776851. The goal of the project is to prove at large scale the feasibility of innovative circular business models applied to E&HEVs, that enable the offering of new highly customized and performance-based mobility services for European citizens. Such services and business models will affect customers' behavior and will drastically change the current End-of-Life vehicles value-chain towards sustainability.

The **main objectives** of the Project are:

1) Establish three **new circular European value chains** for the re-use, remanufacturing and selective recycling of high added-value parts of E&HEVs (batteries, metals and techno-polymeric components).
2) Generate **new service markets** for the sustainable mobility of European citizens. New services will rely on the **exploitation of the opportunities of circular economy** on the one hand, and will be a necessary market for the **long-term sustainability of circular business models** on the other.
3) **Demonstrate at European scale the economic, social, and environmental sustainability** of new circular business models and services, taking into account potential drawbacks and side effects.
4) Create the conditions for a **European wide exploitation of results**.

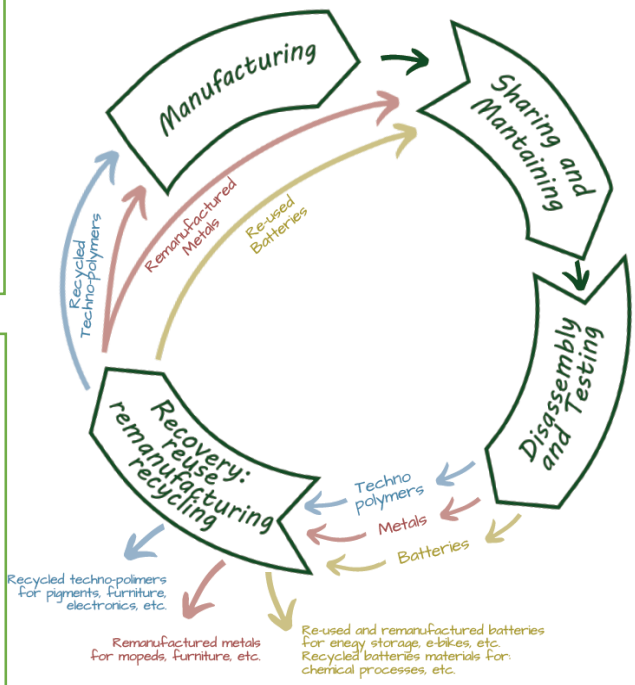
CarE-Service Circular Business Model Development

Manufacturing E&EHVs

Thanks to innovative circular economy practices key parts and components of E&HEV including batteries, metals and techno-polymers will be re-designed and manufactured so that they can be easily disassembled, remanufactured, and recycled. Moreover, recovered parts and materials will be used in the production of new or remanufactured vehicles.

Recovery E&HEVs

Disassembled parts of the vehicles such as batteries, metals and techno-polymers that cannot be instantly re-used will be recovered through different circular economy approaches of recycling and remanufacturing and they will be used in the automotive industry or other sectors.
The CarE-Service platform will support operation and logistics as well as the purchase of recovered parts.



Sharing and maintaining

The use of E&HEV in car-sharing will be made, maintained and upgraded with recovered parts and materials so that not only fleet costs will considerably decrease, but also car sharing will be more environmentally, economically and socially sustainable.
An ICT Platform will support a marketplace where re-used, re-manufactured and recycled parts are marketed for fleet management.

Disassembly and testing

At the EoL of E&HEVs, valuable parts will be disassembled through Smart Movable Modules (SMMs). SMMs are trucks with advanced equipment for disassembling key components and testing/certifying the parts to be used by maintenance workshops/ re-manufacturers or other companies in the recovery value chain provided through the CarE-Service market

CarE-Service Mobility Services

At present car ownership is still the preferred option by customers. However, due to the recent debates on climate change, people are more environmentally conscious and wish to reduce their carbon footprint. Thus, both manufacturers and consumers are urged to reconsider their car-use models towards more sustainable and circular business models, such as electrical car-sharing and leasing/renting programs.
In CarE-Service project parts expertise in circular Business Model Linköping University (LiU) and (National Research Council of Italy) STIIMA-CNR are designing an innovative circular economy business model based on customized mobility services which could enhance the diffusion of circular economy practices for EVs. E-VAI electric sharing mobility services company implements its experience on using EVs as sharing mobility providers to testify the sustainability of multi-modality services within the designed business model through the project. Such services will be based on:

- ★ **Non-ownership business model** (electric and hybrid electric car sharing)
- ★ **Performance oriented** (improve user experience and citizens' quality of life)
- ★ **High customization** (service will be offered to both private and business customers in urban and rural areas)
- ★ **Multi-modal system** (combination of hybrid and electric cars, electric mopeds, motor bikes and public transportation)

Circular Economy of Battery Recovery in EVs

The automotive Lithium-ion battery (LIB) pack represents one third of the total cost of an EV and, due to the exponential transition to e-mobility in recent years, it is starting to attract attention for sustainable EoL management. Many challenges have pushed researchers and companies to study and develop innovative solutions enabling Circular Economy, made attractive by the significant LIBs market demand and the cost of raw materials. In the case of reuse and remanufacturing activities, for example, the possibility to exploit residual properties in other less-demanding sectors is the main driving factor. This is being achieved despite the current limitations given by the product safety issues and the original pack designs which act as barriers for the disassembly phase, in terms of presence of irreversible joints or inaccessibility of electrodes for components testing. LIB recycling, on the other hand, is advantageous for the recovery of valuable metals (i.e. Cobalt) as secondary raw materials, but is very far from a well-defined and optimized technically and economically sustainable process, due to the huge variability of structures and compositions. Recycling also prevents spreading of hazardous substances to the environment.

Within CarE-Service project, all the post-use treatment steps enabling a Circular Economy approach are being investigated by collaboration of partners from STIIMA-CNR and Spanish National Research Council (CSIC) , in order to develop innovative processes and technologies. Through the battery recovery plan project receives the battery supply supports from Fiat Chrysler Automobiles (FCA) the OEM project partner. The facilitation of reuse and remanufacturing activities started with the analysis of disassembly tasks by Joint Research Center (JRC) and Envirobat Espana expertise and know-how knowledge, creating Standard Operational Sheets to support a human-robot collaboration during battery dismantling from pack level all the way to individual cells. Testing procedures able to balance the industrial requirements with the proper technical accuracy have been developed in order to estimate the residual LIB properties for second life. This information allows novel SMM that collaboratively investigated by CIA Robatic and IMA technologies, units to supply an automated service, available on site.

Finally, for remanufacturing, re-engineering techniques are being developed with the intention to produce a variation of second life battery prototypes, each specifically designed for different second life application. Also, with the use of common testing techniques, additional flexibility can be applied in the form of varying battery types. The process will also be optimized with the use of human-robot collaborations and is complemented with a decision support system (DSS) capable of aiding battery redesign based on market needs.

On the other hand, in the battery recovery value chain not only the knowledge and expertise from technological side have been collaboratively investigated but also from market demand and high growing technologies by consulting Avicenne has been inspected as well as maintaining the regulation of the battery responsibility by envisioning the legislation and standards by COBSER partner experienced in collection and transportation of battery EoL.

Circular Economy of Battery Recovery schematic

Read our paper for a complete overview of LIBs recycling here!

Circular Economy of Techno-polymer Components in EVs

Techno-polymer components which are made of advanced polymers with high mechanical properties and low weight are an important part of EVs. To moderate the increased weight of EVs due to heavy batteries, the percentage of techno-polymers in E&HEVs will be higher than in traditional combustion vehicles. Therefore, it is estimated that the techno-polymer components will increase substantially in the coming years in e-mobility industry.

RadiciGroup, partner of CarE-Service project - active in the chemical, engineering plastics and synthetic fiber sectors- developed a solution in which the value of products and materials is maintained for as long as possible. Wastes and resources used are minimized, and when a product reaches the end of its life, it is used again to create further value. The first and fundamental element of this process is the eco-design of products.

By these bases, in the last years, we have been observing a steadily growing demand for products with a lower environmental impact, which embeds the principles of the circular economy (recycle once they reach EoL).

The post-industrial products were used to develop the technologies to perform the post-consumer recycling. This latter, performed in an efficient way starting from components dismantled from EoL vehicles, represents the challenge to make possible the circular economy business model. The resultant materials will be applied to produce new components to be reintroduced into the automotive sector, or in others. The recycling for the materials re-use, to reduce the incineration and the landfill dispersion, represents the strategic objectives for the industries and the institutions. Currently, the feasibility study of the recycling process is in the advanced stage and considers the requirements of the applications where the post-consumer materials are aimed. The final goal will be to promote virtuous recycling, achieving the circular economy business by re-using these recovered materials.

Thanks to RadiciGroup **chemical know-how** and **vertical integration** in these first two years of the European project, the project has been focusing on the most promising recyclable components, as wheel covers and airbags.

Wheel covers ready to be recycled

These components are selected considering the disassembly easiness, techno-polymer weight, and purity. After disassembling, cleaning, and metal separation phases, to characterize the raw materials in input, the main quantity was divided by brands, base polymer and painted or not painted components. This activity was performed in order to reduce the properties variability of the post-consumer recycled material and to preserve the material performances in its second life. Until now, after numerous raw materials analysis and formulation tunings, five different (and tested) products have been achieved and the next challenge is to find ten applications.

Circular Economy of Metal Parts in EVs

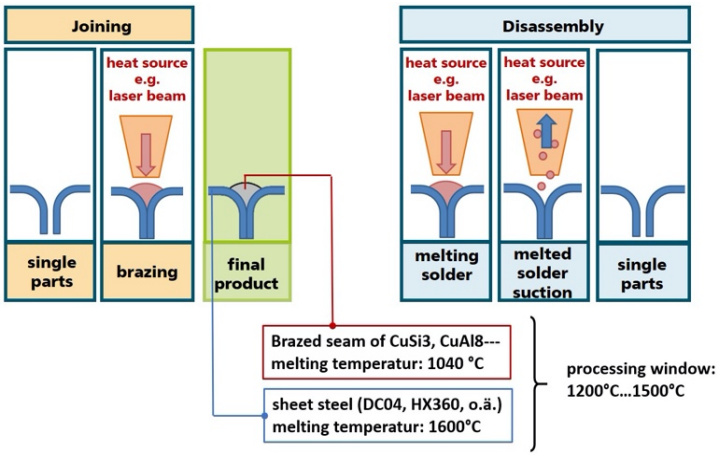
Electrical and Hybrid Electric Vehicles (E&HEVs) are made of several types of reusable metallic parts and components which account for 60-70% of the vehicle weight. According to the current state of the art, car bodies are conventionally recycled. However, recycling is an energy intensive process and fairly costly. This means that the car bodies are pressed into a cuboid after the interior has been removed by the car dismantler. This process step is

known as compaction. After compaction, the pressed cubes are transported to fractionation. In this process, the cubes are shredded and ferrous metals are separated from non-ferrous and synthetic materials. The obtained pure scrap-metal is transported to the steelworks, melted down, casted into a slab and rolled into a coil. The coil is transported to the OEM and supplier companies and further processed into new car bodies.

In order to save energy and thus to reduce the **emission of greenhouse gases, strategies for** remanufacturing car bodies are being developed as part of the CarE-Service project by Fraunhofer expertise.

One objective is the technological development of disconnectable joints in body construction, which fulfil the economic requirements of the OEM, should enable the non-destructive dismantling of bodies. Established disconnectable joints are primarily screws and bolts. Due to the complex assembly, the optical requirements of the bodywork as well as the high costs, screws were replaced by largely welding, soldering, gluing and riveting in car body construction years ago. The only way of disconnecting of welded and rivet joints is by damaging the components.

aser brazing is a joining technology that has been established in bodywork for many years. Due to the high seam quality, the high connection strength, the very good reproducibility as well as the good automatability, laser brazing is established in the automotive industry. Hard solders (e.g. CuSi3, CuAl8 or similar) are generated at joining temperatures of about 900-950 °C by laser processing optics. Due to the significantly higher melting temperature of steel (about 1600°C), it results in a process window of approx. 1200-1500 ° C in which the brazed seem can be liquefied and removed without significantly damaging the steel components.



Schematic representation of the process

In order to be able to carry out this process economically, a special laser processing optic is being developed by Fraunhofer IWU laboratory in the CarE-Service project. The soldering seam is heated up to the melting temperature by a focused laser beam and the liquefied solder is blown out through a gas nozzle. The process is supported by a temperature-dependent regulation of the laser power. Since the processing optics can be guided by an industrial robot, the process can be designed to be very flexible.

CarE-Service Smart Movable Modules (SMMs)

The Smart Movable Modules (SMMs) are one of the most innovative ideas of CarE-Service project. SMMs are trucks equipped with robots and advanced equipment which consist of **disassembly SMM**, for dismantling the battery of the electric vehicle as well as **testing and certification SMM** for testing the quality of dismantled battery, metal and techno-polymer parts.

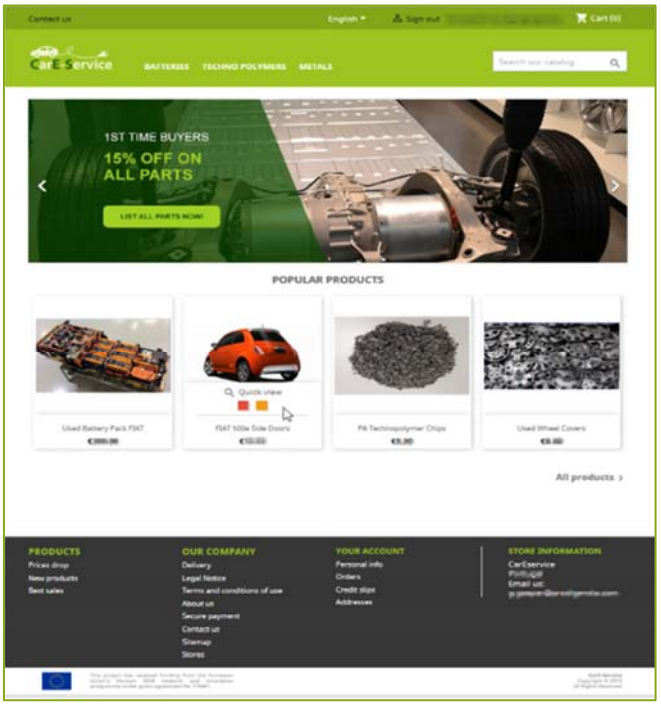
SMMs are smart and through communication with the sensors integrated in the vehicle they will scan and retrieve data on the use condition of the vehicle. This way, they plan and optimize the disassembly and testing process.

The technology developed through the modules are being carried out by partners CIA to design the robots for disassembly and IMA to manage the

testing requirements for the EoL disassembled EVs parts.
SMMs will be connected in the cloud with the CarE-Service platform, so that the availability of disassembled and tested parts could be shown for re-use, remanufacturing and recycling.

CarE-Service ICT Platform

The marketplace is the central component of the ICT platform, where the demand for used, remanufactured and recycled parts and materials of EVs meets the supply. Through the Platfom, the companies in charge of EVs EoL management are able to book a disassembly SMM and, with its service, extract the valuable components out of an EoL EV, test them with the support of a testing SMM and make them available for sale in the marketplace. The products are characterized, and can be sold for second use, remanufacturing, recycling and so on, according to their properties and customer requirements. Buyers can enter the marketplace, see the available products, buy tested products, request for non-offered products, and request for shipping for the products they buy.
The CarE-Service ICT-platform is formed by different IT products.
The main components are the following:
• The marketplace,
• The SMM client application (for both dismantling and testing SMM),
• The SMM booking application,
• The logistic component, responsible for the shipment of the goods which are traded in the marketplace.
Software implementation is being carried out by Circular Economy Solutions GmbH (C-ECO) and Prodigentia SA (PROD), two partners with expertise in circular economy software solutions.
The marketplace, the logistic module and the client application of the dismantling SMM are in the final stages of development and partially completed while the SMM booking application, the client application of the testing SMM and the Decision Support System (DSS) (which is responsible for defining the potential future use of the tested parts) are still under development.



ICT Platform Design

What's next in CarE-Service?

- ★ Identification of stakeholder's groups and the collaboration in the project
- ★ Battery position paper with the updating results
- ★ New and advanced technologies developed through metal non-structural parts

The CarE-Service Project Impacts

The project will generate **economic impacts** by creating:

- markets for new mobility services and market for hybrid and electric vehicles;
- new recovery/recycling businesses in the automotive sector and in other sectors;
- new reusing/recycling technologies;

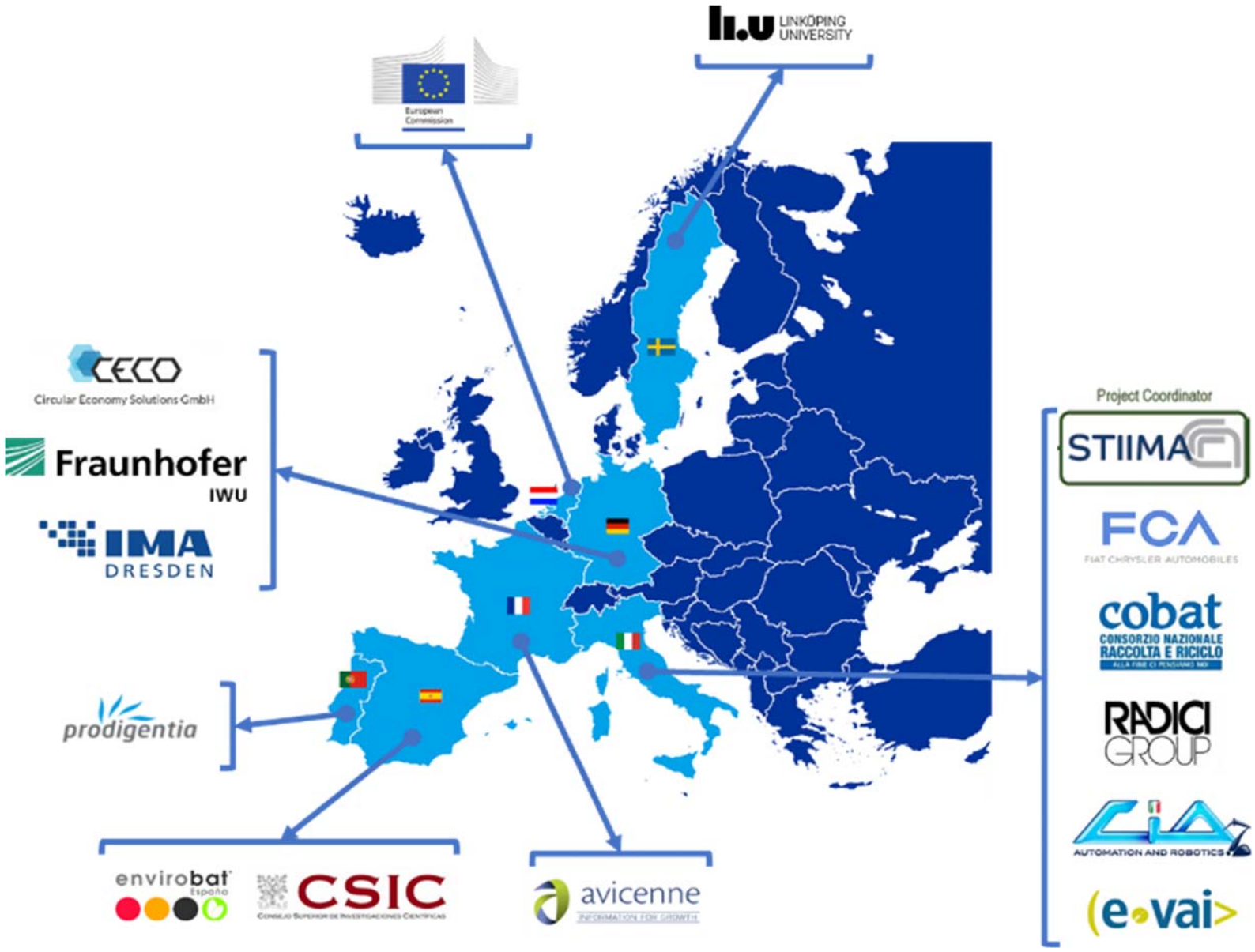
It will generate positive **environmental impacts** due to:

- the introduction of systemic reuse/recycling practices for hybrid and electric vehicles;
- the use of hybrid and electric vehicles waste in other recycling chain outside automotive;
- the wider diffusion of hybrid and electric vehicles in substitution to traditional combustion vehicles.

Finally, the project will generate significant **strategic impacts** since Europe will have the possibility to:

- become a global leader in recycling hybrid and electric vehicles;
- become a global leader in reuse and recycling technologies;
- contribute to a cultural change in the direction of more sustainable transportation and improve the quality of life of citizens.

Project Partners



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Join our "Stakeholders' Group" and "Consumers' Committee"