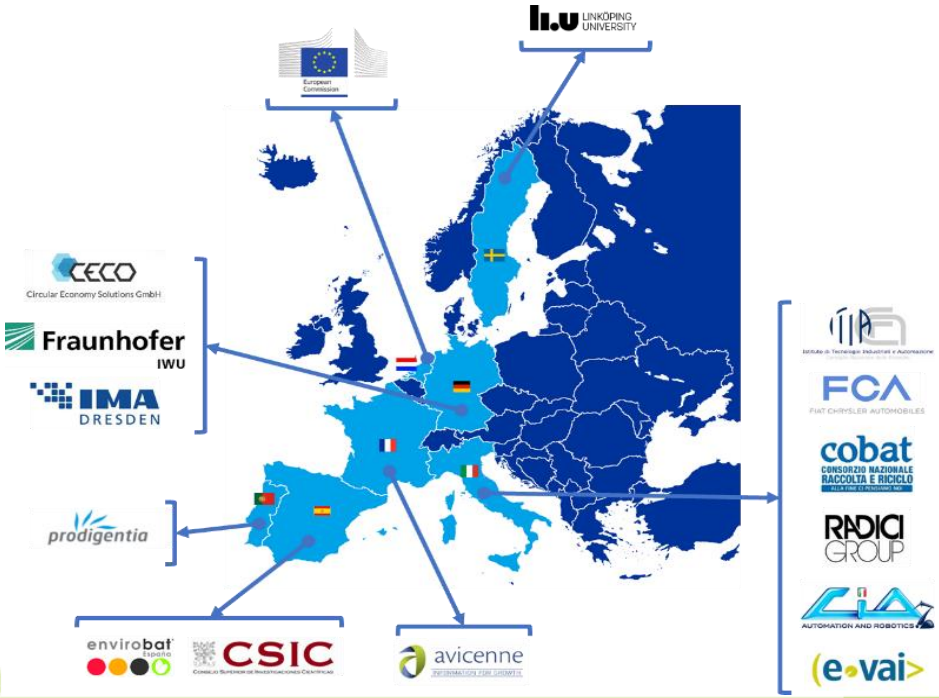
CarE-Service

Circular Economy oriented services for re-use and remanufacturing of hybrid and electric vehicles components through smart and movable modules

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776851

Project figures

No	Name	Country
1	CONSIGLIO NAZIONALE DELLE RICERCHE* - Coordinator	Italy
2	LINKOPINGS UNIVERSITET	Sweden
3	ENVIROBAT ESPANA SL	Spain
4	PRODIGENTIA - TECNOLOGIAS DE INFORMACAO SA	Portugal
5	AGENCIA ESTATAL CONSEJO SUPERIOR DEINVESTIGACIONES CIENTIFICAS	Spain
6	CIRCULAR ECONOMY SOLUTIONS GMBH	Germany
7	COBAT SERVIZI	Italy
8	FIAT CHRYSLER AUTOMOBILES ITALY SPA	Italy
9	RADICI NOVACIPS SPA	Italy
10	IMA MATERIALFORSCHUNG UND ANWENDUNGSTECHNIK GMBH	Germany
11	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V	Germany
12	AVICENNE DEVELOPPEMENT	France
13	CIA AUTOMATION AND ROBOTICS SRL	Italy
14	E-VAI SRL	Italy
15	JRC -JOINT RESEARCH CENTREEUROPEAN COMMISSION	Belgium



- 15 Partners
- 7 Countries
- Costs: 7,7 mln€
- EU Funding: 6,2 mln€
- From June 2018 to May 2021 (3 years)
- Coordinator: Giacomo Copani (CNR-STIIMA)

Current and future challenges

High Total Cost of Ownership of E&HEVs

€

- High initial cost of E&HEVs due to battery and other high added-value materials and components
- Battery life
- Maintenance cost

Users' experience

- Vehicle performance and autonomy
- Maintenance need
- Recharging stations
- ….

End-Of-Life

EU is not currently prepared to efficiently manage the EOL of E&HEVs:

- No consolidated processes and technologies for E&HEVs EOL
- No value chains for E&HEVs EOL

CarE-Service

Re-use technologies for Li-Ion batteries

Dismantling technology for disassembly of batteries

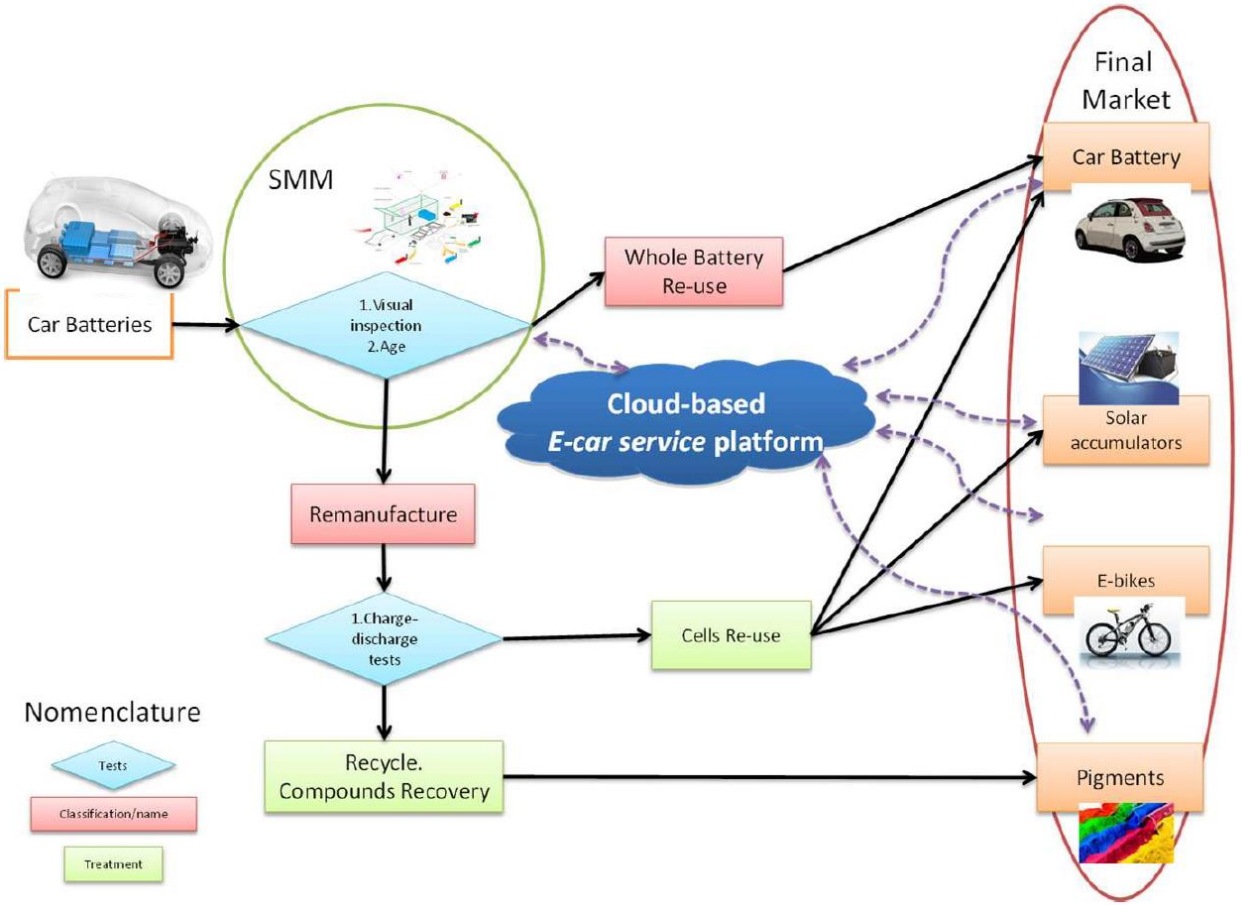
Human-robot cooperation to separate plastic, wires, electronic controllers and cell batteries

Testing technology and algorithms to predict residual life

Charge/discharge cell behaviour test, protocols and software for assessing battery SoH

Compounds recovery technology

Hydrometallurgy to sustainably recover Li, Co, Mn, Al, etc.



Re-use in other applications

Solar panels, e-bikes, pigments, etc.

Smart Mobile Modules

Mobile units bringing advanced technology for on-site disassembly and testing/certification where is the demand

Disassembly Module

- DSS suggesting which components to disassemble based on car sensors data, manufacturer product data and market
- Disassembly guidelines
- Robotics cooperative disassembly
- Mechatronics tools

Testing Module

Functional, geometric, mechanical and electric testing methods and technologies for:

- Certification of re-usable parts
- Testing of components and parts for remanufacturing
- estimation of the type and content of high value-added materials for recycling

New mobility products-services

- **Non-ownership**:
  - car sharing, renting, leasing
- **Performance-oriented**:
  - Responsibility of the service provider for vehicle availability and performance
  - Quality reward criteria for customers returning vehicles
- **Exploiting benefits of circular economy**:
  - Reduced cost of spares
  - Reduced cost of vehicles built with re-usable parts
  - Continuous functional and aesthetic upgrade of parts through remanufacturing/refurbishing at low cost
- **High market segmentation**

Benefits for customers:

- higher affordability
- better assistance
- Increased overall transportation performance
- improved user experience

Re-use technologies for metal parts

New flexible joining technologies

Disassemble and re-assemble modules of structural metal parts as spares or restyled models elements

Cold reforming of external non-structural elements

Obtain new parts to use as spares or to upgrade vehicles aesthetics at sustainable conditions

Re-use technologies for techno-polymers

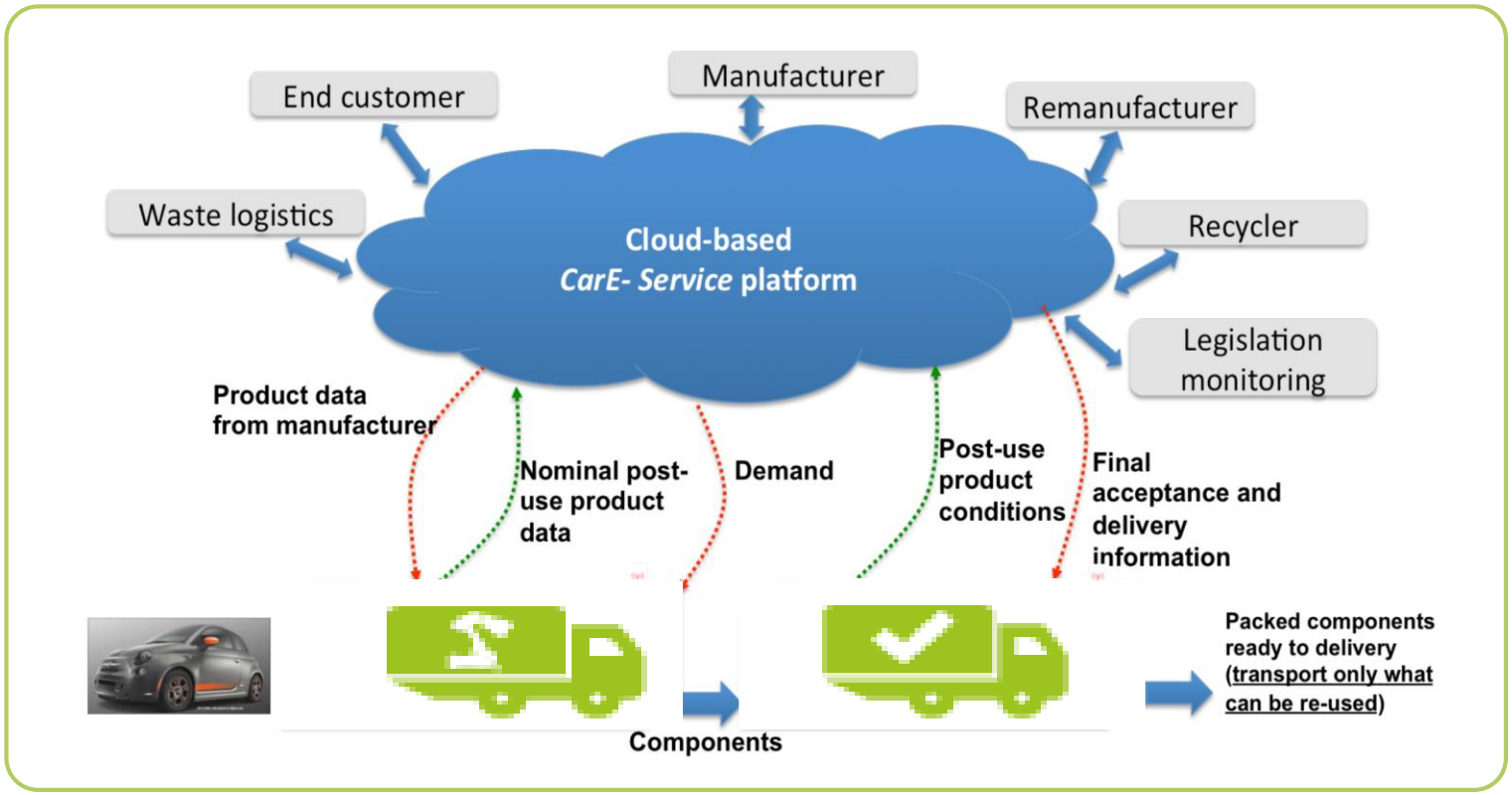



New recycling process for techno-polymers

- Separation of metal sub-parts
- Grinding of new formulation compounds
- Extrusion for transformation of new parts (for automotive and other sectors such as furniture, design, etc.)
- Testing of materials properties

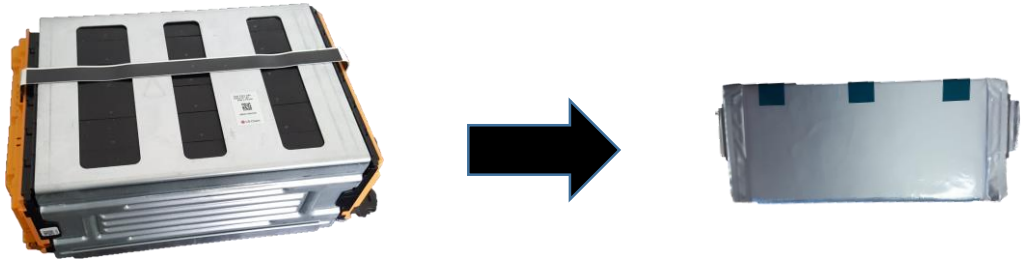
CarE-Service ICT Platform

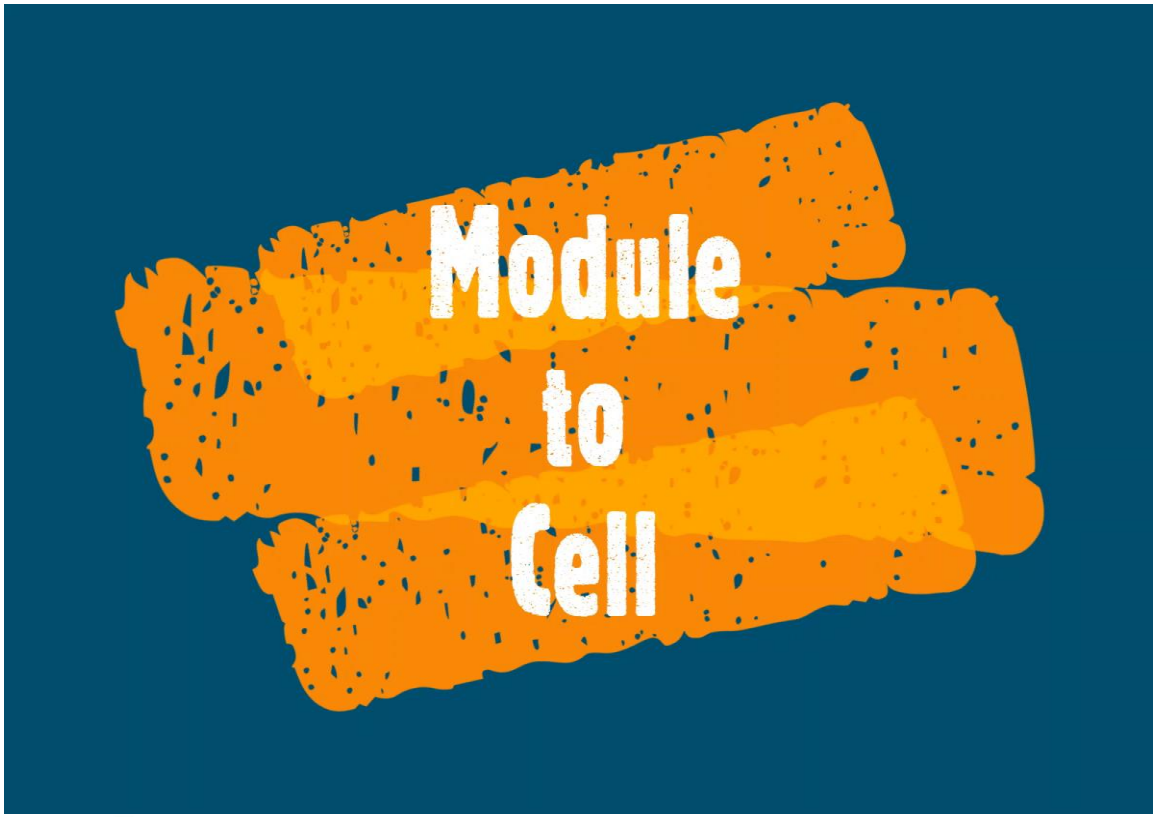
ICT Platform connecting demand and supply of re-usable parts and allowing the coordination and optimization of the re-use value chain



Re-design dei moduli

Dismantling – Module to Cell





GENERAL PROTOCOL

Step	Task	Level	Time	Safety equipment
1	Removal of the external protection cases	From: **pack** To: **module**	Min: 5mins Max: 30mins	High voltage gloves Safety glasses
2	Identification and detachment of service plugs and fuses to secure the battery		Min: seconds Max: 3mins	High voltage gloves Safety glasses
3	Removal of cooling system, if available		Min: 5mins Max: 20mins	High voltage gloves Safety glasses
4	Detachment of modules from the high voltage connections		Min: 3mins Max: 30mins	High voltage gloves Safety glasses
5	Disconnection of the modules from BMS electric connections		Min: 2mins Max: 15mins	Safety glasses
6	Liberation of the modules		Min: 2mins Max: 30mins	Safety glasses
7	Removal of module external casing		Min: 0 Max: 10mins	Safety glasses
8	Detachment of cell electronics and wiring	From: **module** To: **cells**	Min: 3mins Max: 5mins	Safety glasses
9	Detachment of electrical busbar joints		Min: 2mins Max:30mins	Safety glasses
10	Liberation of cells from supporting casing		Min: 2mins Max: 20mins	Safety glasses

SOS- Standard Operational Sheets

Task	Level	Strategies	Examples
Removal of module external case	From: **MODULE** To: **CELLS**	**METALLIC CASE** If the external case is joint together it is cut and removed. Required time: 20mins Possible criticalities: risk to damage the cells	
		CLAMPS A plastic cover could protect terminals and should be removed applying a leverage Required time: seconds Possible criticalities: the operation exposes components having a voltage	
		SCREWS Unscrew screws and fold tabs in. Then remove case Screws amount: 2-4 Required time: 2-5mins Possible criticalities: safety, damage cells	

SMALL SCALE: Ventilator

Remanufacturing

DEVICE POWERED:

Simple and low cost ventilator, RESPIREM, for COVID-19 and other diseases

ELECTRICAL REQUIREMENTS:

12 V DC, 5 A

APPLICATION:

Electric back-up in case of power supply cut.

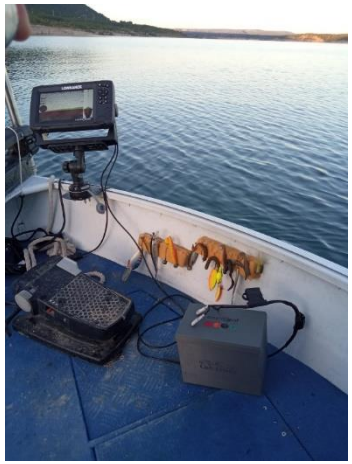
Portable power supply in emergencies and field hospitals.

SMALL SCALE: Other examples

Remanufacturing

Cool box

Sonar device



Vacuum pump

LARGE SCALE: Street lighting stationary storage system

Remanufacturing

DEVICE POWERED:

23 streetlights

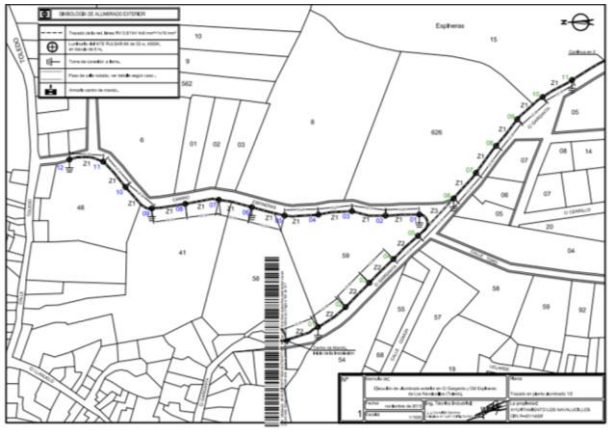
ELECTRICAL REQUIREMENTS:

400 V AC
Up to 18 h autonomy
3 days in a row

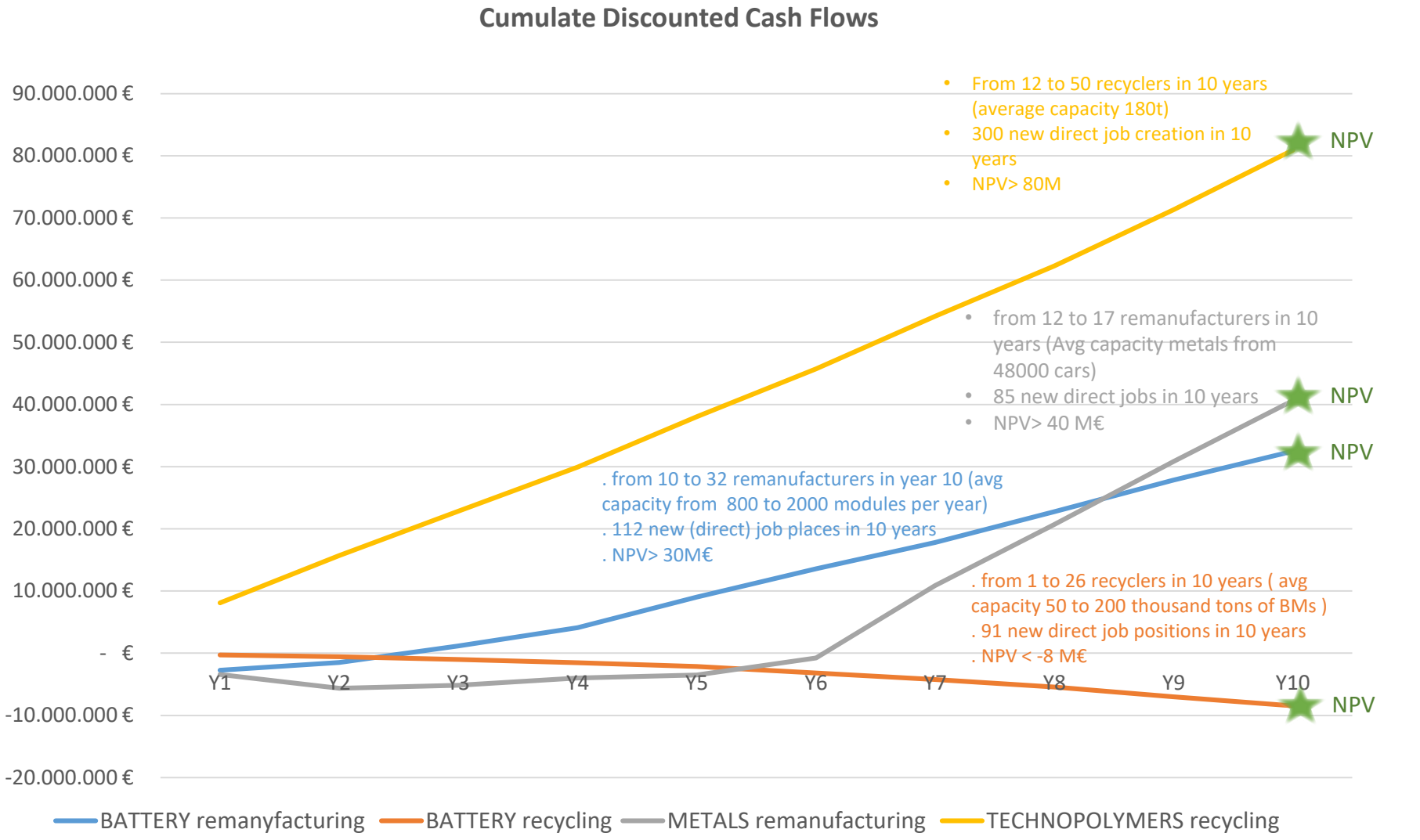
APPLICATION:

Cycle path illumination in

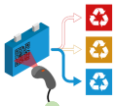
Los Navalucillos (Toledo)



Business Models and Eco-env assessment of re-use value chains



CarE-Service proposals on legislation



Labelling

- Additional **fundamental features** of the battery pack
- Battery **QR Code**

Repurposing and remanufacturing

- Battery Management System (BMS) **accessibility**
- EoL EV battery **no longer considered waste**

Recycling efficiencies and recycled content

- Secure **access to secondary raw materials** through recycling
- **Potential impacts** of the most relevant recycling processes
- Avoid a **potential slowing** of the EU production market

Extended Producer Responsibility

- EPR battery transferability
- EV batteries **National Register**

Battery Passport

- **Connection** with Labelling and QR code
- Full **accessibility** to the Battery Passport

CarE-Service proposals on standardization

Semi-automated battery disassembly

Standardized semi-automated procedure for a non-destructive disassembly

Recycling efficiency calculation

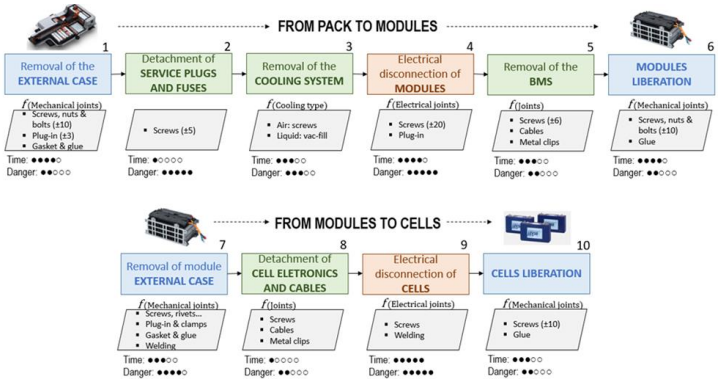
RE calculation must include:

- f_E: energy consumption factor
- f_{NRAi} : natural resources availability
- f_{CO2}: greenhouse gas emissions

$$R_E = \frac{\sum\left(m_{output_i} \cdot f_{NRA_i}\right)}{m_{input}} \cdot f_E \cdot f_{CO_2} \times 100, \text{[mass \%]}$$

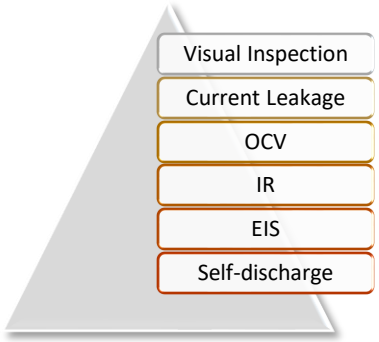
SOS for manual battery disassembly

Standard Operational Sheet for complete battery pack disassembly



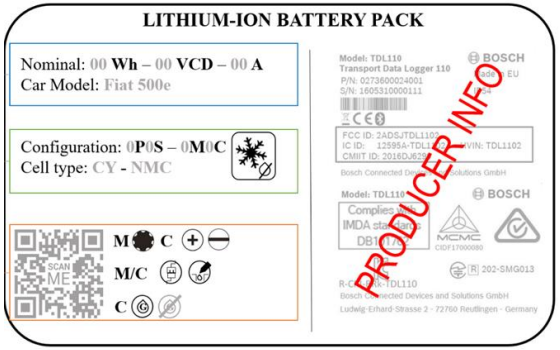
Battery testing

Standardized classification testing protocol



Battery re-design

Standardized pack and module labelling



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

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