D1.4: Industrial use cases and scenarios design (2nd version)

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EXECUTIVE SUMMARY

The main aim of the TREASURE project is testing innovative technologies to make the automotive sector more circular. To this aim, TREASURE wants to implement an AI-based scenario assessment tool supporting the development of circular supply chains in the automotive sector. Through a set of success stories coming from the application of circular economy principles in three key automotive-related value chains, TREASURE wants to demonstrate in practice the real benefits coming from the adoption of circular behaviours. In addition, Key Enabling Technologies (KETs) will be integrated within the selected processes to support the efficient design of car electronics and its subsequent disassembly and materials recovery.

Deliverable 1.4 “Industrial use cases and scenarios design” is the second deliverable related to activities done in Task 1.3 within WP1 “Reference Framework definition”. The objective of D1.4 is to add details about what already described in D1.3, by gathering additional key inputs from other activities implemented in WP1 (e.g. reference framework and TREASURE platform requirements & specifications), WP2 (e.g. sustainability & circularity-related methodologies definition) and WP3 (e.g. disassemblability and recyclability analyses and KPIs). Starting from all these findings, some detailed specifications for the development of the demonstrators (WP6) will be laid down, by establishing boundaries and main goals characterizing the TREASURE solution and its integration within the different pilots.

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1. Introduction

Starting from the information reported in D1.3, D1.4 wants to complete the description of each use case. The intent of this document is, hence, to present each use case in detail, by following a standardized logic and identify the related requirements. The final purpose of these use cases is bringing together knowledge, tools and technologies developed in other WPs and demonstrating their benefits into practice, by covering three different stages in the automotive value chain. To this aim, the reference logic adopted for the description of each use case comes from the Circular Car Initiative (CCI) report on circular business models in the automotive sector[2]. A description of the table extracted from the CCI report has been already presented in D1.3. The same table is reported hereafter just for clarity reasons.

Figure 1 - CCI report-like pilot project idea details

Solution: • XXX	**Transformation pathway:** • XXX	**Impact on measures:** • XXX • XXX

Pilot objective: • xxx	Enablers & synergies: • xxx
Benefits: • xxx	Owners & contributors: • Owner: xxx • Contributors: xxx
Barriers: • xxx	Next steps: 1. Xxx 2. Xxx 3. Xxx 4. xxx

1.1. Scope of the deliverable

D1.4 "Industrial use cases and scenarios design" is the second deliverable associated to Task 1.3 focused on the description of the TREASURE's industrial use cases. Starting from the findings provided by D1.1 and D1.2 (in terms of reference framework and platform requirements), D2.1 and D2.2 (in terms of sustainability and circularity methodologies), D3.1, D3.2, D3.3 and D3.4 (in terms of disassemblability and recyclability assessment and KPIs), D1.4 provides a complete overview of the TREASURE industrial use cases.

Working together with other WPs, use case scenarios have been analysed, deeply investigating how the TREASURE solutions could support the transition from the AS-IS to the TO-BE scenarios. Hence, D1.4 identifies the different scenarios to be implemented considering the targeted stakeholders. Together with the business requirements, this document adds more information (e.g. validation targets, evaluation procedures, main activities, KPIs) related to each use case to give a complete overview of each of them.

1.2. Contributions to other WPs

The whole industrial use cases implementation will be split into two work packages. Within WP5, a set of lab-scaled activities will identify the most suitable solutions to implement. In addition, these solutions will be optimized to treat automotive components and materials. Within WP6, the available solutions will be tested together with the TREASURE industrial partners, by

[2] https://www.weforum.org/reports/raising-ambitions-a-new-roadmap-for-the-automotive-circular-economy

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comparing the benefits coming from their adoption with current performances (especially in terms of sustainability and circularity). Therefore, this deliverable is directly related to the following work packages:

- WP5 "Pilot plants reconfiguration/optimization": D1.4 completes the industrial use cases requirements and provides an overall picture of the pilots and their testing environment.
- WP6 "Validation & demonstration": D1.4 mainly provides a complete scenarios definition in order to set up the different validation & demonstration activities together with the industrial partners involved in TREASURE.

1.3. The TREASURE use case description table

Starting from the information fields related with the previous Figure 1, TREASURE defined a similar table in order to classify and monitor the different use cases developed during the project. The TREASURE use case description table has been already described in D1.3 and is reported below just for clarity reasons.

Figure 2 – The TREASURE use case description table

Objective: • XXX	**Owner & contributors:** • XXX	**Expected impacts:** • XXX • XXX

Industrial requirements: • Xxx	Use case specifics: • Xxx
TREASURE platform integration boundaries: • Xxx	TREASURE platform integration goals: • Xxx
Validation targets: • Xxx	Evaluation procedures: • Xxx
Activities: • Xxx	KPIs: • Xxx

*RED = described in D1.2 and D1.3

Within D1.4, only validation targets, evaluation procedures, activities and KPIs will be described in the following sections. Industrial requirements and use case specifics have been already described in D1.3. Platform's integration boundaries and integration goals have been already described in D1.2.

2. Participants and facilities

The following table provides a comprehensive description of the involved partners and the list of facilities that are going to be exploited in each use case.

Table 1 – List of partners and facilities in each use case

ID	Location	Leader	Involved partners	Reference facility
DIS	ITA	POLIMI	POLLINI, TXT, MARAS, SEAT, EUROLCDS	POLIMI's I4.0 Lab
REC	ITA	UNIVAQ	EUROLCDS, TXT, MARAS, SEAT, ILSSA, UNIZAR	UNIVAQ's pilot plant
ECO	NED	TNO	WALTER, TXT, MARAS, SEAT, EUROLCDS	TNO's Lab

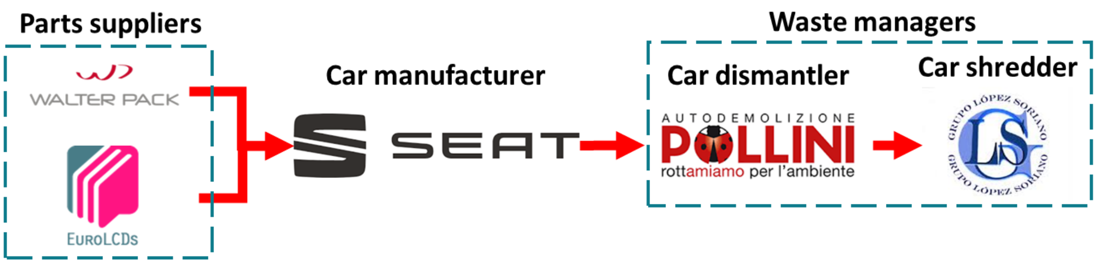
ID detailed description:

- **DIS:** Italian use case on car electronics disassembly
- **REC:** Italian use case on car electronics material recovery
- **ECO:** Dutch use case on in-mold/structural electronics eco-design

2.1. TREASURE actors' value chain

The following picture summarizes the role of each TREASURE's industrial partner involved in each of the previous use cases within the automotive value chain. A description of each partner has been already proposed in D1.3.

Figure 3 – The TREASURE's automotive value chain



2.2. Use cases positioning

As already mentioned in D1.3, the three use cases developed in TREASURE are mainly covering the Beginning of Life (BoL) and End-of-Life (EoL) stages of car electronics' lifecycle. Specifically, DIS and REC use cases are focusing on disassembly and materials recovery, respectively. Instead, the ECO use case is focusing on eco-design of in-mold/structural electronics.

3. Industrial use cases and scenarios design

Within the TREASURE project, three industrial use cases have been identified. They are related to car electronics disassembly, car electronics recycling and eco-design of IMSE prototypes for new applications (possibly in the automotive sector). Within this section, the description of these use cases (already presented in D1.3) will be completed, by filling in those fields reported by the TREASURE use case description table not considered in the previous version of this document. In order to gather additional (lacking) information from the industrial partners, three workshops (one per each use case) have been organized by POLIMI in September 2022.

3.1. Car electronics disassembly processes (DIS use case)

The first use case (named DIS) refers to car electronics disassembly processes. DIS will consider five car electronics components selected by SEAT (see D1.3 and D3.1 for details) and manually disassembled from ELVs by ILSSA (see D3.2 for details). Within the DIS use case, the disassembly of car electronics will go ahead, by desoldering valuable electronic components (e.g. microchips, capacitors, diodes, etc.) from PCBs. This activity will be executed by POLLINI (supported by POLIMI and TXT). Specifics about the PCB semi-automated disassembly process adopted in TREASURE have been embedded in a separate document. Both the AS-IS scenario & challenges, owners & contributors and the expected impact of the solution have been already discussed in D1.3. The following tables report the list of results from other WPs and reference modules of the TREASURE platform to be adopted and exploited in the DIS use case.

Table 2 – List of applied results from previous WPs in the DIS use case

Applied results from other WPs/Tasks	WP	Task	Task Leader
Sustainability & circularity assessment methods and KPIs	WP2	T2.1, T2.2	SUPSI
Disassemblability analysis, guidelines & integration with CE indexes	WP3	T3.1, T3.2, T3.4	SEAT, ILSSA, UNIZAR
Simulation, lab-scale tests & optimized disassembly procedures	WP5	T5.1, T5.2	POLIMI

Table 3 – List of reference modules and technologies applied in the DIS use case

Reference TREASURE platform's module
Disassemblability module
Reference technology/asset
POLIMI's PCB semi-automated disassembly cell (ref. FENIX project)

2.1.1. Activities

The following bullet list summarizes the main activities to be implemented within the DIS use case:

- Train POLLINI's operators on how I4.0 technologies can support the development of new disassembly procedures focused on car electronics.
- Train POLLINI's operators in order to run the pilot station independently.
- Compare new disassembly process performances with current ones in terms of circularity levels, by exploiting TREASURE platform's potentialities.

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- Assess different disassembly routes according to methodologies and guidelines established in WP2 and WP3, respectively.
- Validate circularity performances through established KPIs.
- Provide recommendations for advised disassembly directions/options to optimize recycling/recovery based on EoL recycling options.

2.1.2. Validation targets

Validation targets are directly related to practical use case activities and industrial requirements. They represent an approximate measure of how much the industrial requirements have been met. The following targets have been set for the DIS use case:

- Expected disassembly level of PCBs: desoldering of all the SMD components (if needed)
- Expected overall disassembly time (manual + semi-automated): 30 min/PCB
- Expected training level of operators: operators will manage independently the semi-automated PCB disassembly station implemented by POLIMI
- Expected # of operators involved in semi-automated disassembly processes: 1 operator
- Expected # and type of manual disassembly tools: 5/6 tools, standard tools
- Expected labour cost: 35 €/hour
- Expected energy cost: 0.3 €/KWh
- Expected overall max semi-automated disassembly costs: equal to overall manual disassembly costs
- Expected sustainability/circularity level: better than manual disassembly processes

2.1.3. Evaluation procedures

Evaluation procedures are a list of procedures adopted by each use case team to monitor their activities.

The following bullet list summarizes the evaluation procedures adopted within the DIS use case:

- Circularity assessment: Time-based disassembly analysis (procedure derived from D3.2 and D2.2), Material Recycling Flower (Individual Material Recycling rates)
- Economic assessment: cLCC and Circular Economy Life Cycle Costing (CE-LCC) (if externalities cost are available)
- Environmental assessment: Product Environmental Footprint (PEF)
- Social assessment: UNEP’s Social Life Cycle Assessment (SLCA)

2.1.4. KPIs

The following bullet list reports a set of KPIs to be measured in the DIS use case. The intent of these KPIs is just validating in a real context some of the most relevant performances related with circular procedures. Hence, this list represents just a subset of the KPIs already identified in D3.2 (reporting specific disassembly measures) and D2.2 (reporting specific evaluation procedures). In order to allow a direct comparison, the same KPIs will be measured both in the AS IS (manual disassembly) and TO BE (semi-automated disassembly) scenarios.

- Number of components to be disassembled [#]
- Average disassembly time - real conditions [min]
- Average disassembly time - ideal conditions [min]
- Disassembly yield [%]
- Optimal disassembly depth from EoL perspective:

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  - Disassembly-enabled additional recycling rate per material/element/compound [%]
  - Exergetic performance [MJ/h or kW]
  - Energy recovery [kW]
- Recycling index [%] (also compared to recycling rates of the disassembled part when not disassembled and recycled as entire part)
- Technical feasibility for disassembly
- Difficulty level [evaluated according to D3.2, based on # of manual disassembly tools, standard/non-standard tools, and # of people involved]
- Economic performance (disassembly cost, expected revenue from the disassembly process - thinking about subsequent recycling):
  - Disassembly overall cost = Labour cost [€] + Energy cost [€] + Service cost [€]
  - Revenue from recycled material = Value of recycled material (from market quotations) [€/kg] * material mass (from datasheet) [kg] * Recycling rate/100
- Environmental performance: automation level indicators (to be better investigated)
- Social performance: stakeholder worker indicators (to be better investigated)
- Circularity performance: Disassembly time [min]

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Figure 4 – The DIS use case description table

Objective: • Semi-automated car electronics disassembly	**Owner & contributors:** • **POLIMI** • POLLINI • TXT • MARAS • SEAT • EUROLCDS	**Expected impacts:** • Increase awareness • Improve performances • Provide information • Share knowledge

Validation targets: Expected disassembly time (manual + semi-automated): 30 min/PCB (desoldering of all the SMD components); Expected disassembly level of PCBs: desoldering of all the SMD components; Expected training level of operators: operators will manage independently the semi-automated PCB disassembly station implemented by POLIMI; Expected # of operators involved in semi-automated disassembly processes: 1 operator; Expected # and type of manual disassembly tools: 5/6 tools, standard tools; Expected labour cost: 35 €/hour; Expected energy cost: 0.3 €/KWh; Maximum overall semi-automated disassembly cost: equal to overall manual disassembly cost	**Evaluation procedures:** Circularity assessment: Time-based disassembly analysis (procedure derived from Deliverable 2.2), Material Recycling Flower (Individual Material Recycling rates); Economic assessment: Circular Economy Life Cycle Costing (CE-LCC) (which is based on environmental LCC (e-LCC))
Activities: Train POLLINI's operators on A) how I4.0 technologies can support the development of new disassembly procedures focused on car electronics; B) run the pilot station independently; Compare new disassembly process performances with current ones in terms of circularity levels, by exploiting TREASURE platform's potentialities; Assess different disassembly routes according to guidelines established in WP4; Validate circularity performances through established KPIs; Provide recommendations for advised disassembly directions/options to optimize recycling/recovery based on EoL recycling options.	**KPIs:** Number of components to be disassembled; Average disassembly time – real/ideal conditions; Disassembly yield; Optimal disassembly depth from EoL perspective; Recycling yield; Technical feasibility for disassembly; Difficulty level; Economic performance; Circularity performance

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3.2. Car electronics recycling processes (REC use case)

The second use case refers to car electronics recycling processes. PCBs already disassembled by the DIS use case will be recycled by application of a (bio-) hydrometallurgical processing pilot plant. In addition, In-Mold/Structural Electronics (IMSE) (e.g. printed graphics, thermoformed polycarbonate, encapsulated sensors) supplied by TNO and LCDs samples (e.g. ITO glass, PCBs, Cu connectors) supplied by EUROLCDs will be recycled in the same hydrometallurgical pilot plant in order to check for the reuse of materials in automotive applications. Specifics about the materials recycling process adopted in TREASURE have been embedded in a separate document. Both the AS-IS scenario & challenges, owners & contributors and the expected impact of the solution have been already discussed in D1.3. The following tables report the list of results from other WPs and reference modules of the TREASURE platform to be adopted and exploited in the REC use case.

Table 4 – List of applied results from previous WPs in the REC use case

Applied results from other WPs/Tasks	WP	Task	Task Leader
Sustainability & circularity assessment methods and KPIs	WP2	T2.1, T2.2	SUPSI
Recyclability analysis, guidelines & integration with CE indexes	WP3	T3.3, T3.4	MARAS, UNIZAR
Simulation, lab-scale tests & optimized materials recovery procedures	WP5	T5.3, T5.4	UNIVAQ

Table 5 – List of reference modules and technologies applied in the REC use case

Reference TREASURE platform's module
Recyclability module
Reference technology/asset
UNIVAQ's hydrometallurgical pilot plant (ref. FENIX project)

2.2.1. Activities

The following bullet list summarizes the main activities to be implemented within the REC use case:

- Train ILSSA operators on how to manage and maintain the materials recovery process focused on car electronics.
- Train ILSSA's operators in order to run the pilot plant independently in few weeks (both operating and maintenance handbooks for all the equipment will be provided).
- Compare new materials recovery process performances with current ones in terms of circularity levels, by exploiting TREASURE platform's potentialities.
- Assess different recycling options and material compositions according to guidelines established in WP4.
- Validate circularity performances through established KPIs.

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2.2.2. Validation targets

Validation targets are directly related to practical use case activities and industrial requirements. They represent an approximate measure of how much the industrial requirements have been met. The following targets have been set for the REC use case:

- Metals recovery yields of selected materials
  - Au 80 %
  - Ag 85 %
  - Cu 95 %
  - Sn 80 %
  - In 85 %
- Increase the overall recovery, % respect to the initial mass
- Wastewater reduction 60-70 % (internal recycle and/or reuse after wastewater treatment)
- Reduce the losses of dissolved elements into the wastewater and solvents
- Reduce the use of energy and primary resources (including solvents)
- Grade of recovered metals
  - Au 80-90 %
  - Ag 80 %
  - Cu 90 %
  - Sn-oxide 90 %

2.2.3. Evaluation procedures

The following bullet list summarizes the evaluation procedures adopted within the REC use case:

- Circularity assessment: Recyclability assessment, Recyclability Index (RI), Material Recycling Flower (Individual Material Recycling rates)
- Environmental assessment: Product Environmental Footprint (PEF), Exergy analysis
- Economic assessment: Circular Economy Life Cycle Costing (CE-LCC), (if externalities costs are available)
- Social assessment: UNEP's Social Life Cycle Assessment (SLCA)
- CE&LCSA aggregation approaches:
  - Circular Economy: visualization/graphical methods (e.g. MARAS material recycling flower)
  - Environmental: PEF aggregation approach (weighted sum and external normalization), visualization/graphical methods
  - Economic: CE-LCC aggregation approach, visualization/graphical methods
  - Social: UNEP / PSILCA DB aggregation approach
- CE&LCSA integration / visualization approaches:
  Graphical integration approach

2.2.4. KPIs

The following bullet list reports a set of KPIs to be measured in the DIS use case. The intent of these KPIs is just validating in a real context some of the most relevant performances related with circular procedures. Hence, this list represents just a subset of the KPIs already identified in D3.3 (reporting specific recyclability measures) and D2.2 (reporting specific evaluation procedures). In order to allow a direct comparison, the same KPIs will be measured both in the AS IS (manual disassembly) and TO BE (semi-automated disassembly) scenarios:

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- Recycling index [%] (also compared to recycling rates of the disassembled part when not disassembled and recycled as entire part)
- Metals recovery rates of selected materials [%]
- Non-metals recovery rates of all materials [%]
- Chemical consumption (baseline scenario) [kg/t]
- Chemical consumption after process optimization (internal recycle) [kg/t]
- Energy recovery [kW]
- Energy consumption for ton of treated waste [kWh/t]
- Metals content in the solid residue/output [%]
- Organic and inorganic fractions in the solid residue/output [%]
- Total water necessary for the process (baseline scenario) [m^3/t]
- Water to be treated or to dispose-off = make-up [m^3/t]
- LCA indexes (e.g. Climate change; Acidification; Eutrophication – terrestrial; Eutrophication – aquatic, fresh water; Eutrophication – aquatic, marine; Photochemical ozone formation, human health; Ozone depletion; Resource use – fossils; Water use; Resource use – minerals and metals; Land use; Eco-toxicity – aquatic, fresh water; Human toxicity – non cancer; Human toxicity – cancer)
- Thermodynamic rarity index
- Economic indexes (e.g. CAPEX, OPEX (e.g. labor, energy, service costs), revenue [€/t])
- Financial indexes (e.g. Payback time (PBT) [years], net present value (NPV) [€], internal rate of return (IRR) [%])
- Social LCA indexes (e.g. Avoided social impacts of virgin feedstock extraction and refining on workers (presence of sufficient safety measures) and local communities (level of industrial water used; extraction of fossil fuels; extraction of ores))
- Circularity performance index (e.g. Recycling index; Reuse of the recovered metal for new products)

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Figure 5 – The REC use case description table

Objective: • Car electronics material recovery	**Owner & contributors:** • **UNIVAQ** • EUROLCDS • TXT • MARAS • SEAT	**Expected impacts:** • Increase recovery • Improve performances • Optimize processes

Validation targets: Metals recovery yields (Au, Ag, Cu, Sn, In); Wastewater reduction; Grade of the final product (Au, Ag, Cu, Sn-oxide)	Evaluation procedures: Circularity assessment; Environmental assessment; Economic assessment; Social assessment; CE&LCSA aggregation/integration approaches
Activities: Train ILSSA operators on: A) how to manage and maintain the materials recovery process focused on car electronics, B) how to run the pilot plant independently in few weeks (both operating and maintenance handbooks for all the equipments will be provided); Compare new materials recovery process performances with current ones in terms of circularity levels, by exploiting TREASURE platform's potentialities; Assess different recycling options and material compositions according to guidelines established in WP4; Validate circularity performances through established KPIs.	KPIs: Metals recovery yield (precious/critical/base metals, epoxy resin); Grade of the metal in the final product (hydrometallurgical process); Wastewater production; Waste generation; Use of chemicals; energy consumption; Economic and technical feasibility of the developed recycling processes; Cost analysis; Overall economic performances; Effects of the disassembly on the recycling; # of recovered PCBs; Environmental performances; Social performances; Circularity performances; Reuse of the recovered metals in new products

3.3. In-mold/structural electronics prototyping processes (ECO use case)

The third use case refers to In-Mold/Structural Electronics (IMSE) prototyping processes. Specific materials recovered from both car electronics (e.g. Cu and Ag) and selected plastic car parts (e.g. climate module and mid-console) by the REC use case will be reused in order to produce new in-mould/structural electronics. Specifics about the in-mould/structural electronics prototyping process adopted in TREASURE will be given in D5.5. Simulation models as developed and applied in T3.3 will be applied to assess recyclability and provide technology-based Eco-design recommendations. Both the AS-IS scenario & challenges, owners & contributors and the expected impact of the solution have been already discussed in D1.3. The following tables report the list of results from other WPs and reference modules of the TREASURE platform to be adopted and exploited in the ECO use case.

Table 6 – List of applied results from previous WPs in the ECO use case

Applied results from other WPs/Tasks	WP	Task	Task Leader
Sustainability & circularity assessment methods and KPIs	WP2	T2.1, T2.2	SUPSI
Disassemblability analysis	WP3	T3.2	UNIZAR
Recyclability analysis	WP3	T3.3	MARAS
Eco-design analysis, guidelines & integration with CE indexes	WP3	T3.4	UNIZAR
Simulation, lab-scale tests & optimized IMSE prototyping procedures	WP5	T5.5, T5.6	TNO

Table 7 – List of reference modules and technologies applied in the ECO use case

Reference TREASURE platform's module
Eco-design module
Reference technology/asset
TNO's roll-to-roll line for flexible electronics (ref. InScope project)

2.3.1. Activities

The following bullet list summarizes the main activities to be implemented within the ECO use case:

- Train WALTER, EUROLCDs and SEAT researchers on how in-mold/structural electronics can be exploited in new automotive applications.
- Train WALTER, EUROLCDs and SEAT researchers on green printed electronics production processes and materials.
- Compare green in-mold/structural electronics production process performances with current ones in terms of circularity levels, by exploiting TREASURE platform's potentialities.
- Assess different production processes according to guidelines established in WP4.
- Validate circularity and sustainability performance through established KPIs.

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2.3.2. Validation targets

Validation targets are directly related to practical use case activities and industrial requirements. They represent an approximate measure of how much the industrial requirements have been met. The following targets have been set for the ECO use case:

- Production processes:
  - Reduced power consumption
  - Reduced material usage
  - Reduced /reused/recycled waste
- Recycled materials – compliance to specs:
  - Transparency of recycled plastic, including yellowing
  - Conductivity (if applies)
  - (Thermo-)mechanical properties

2.3.3. Evaluation procedures

The following bullet list summarizes the evaluation procedures adopted within the ECO use case:

- Circularity assessment: Circular Footprint Formula (CFF), Exergy analysis, Recyclability assessment
- Environmental assessment: Product Environmental Footprint (PEF), Life Cycle Assessment (LCA)
- Economic assessment: Circular Economy Life Cycle Costing (CE-LCC) (if externalities costs are available)
- Social assessment: UNEP's Social Life Cycle Assessment (SLCA)
- CE&LCSA aggregation approaches:
  - Circular Economy: CFF aggregation approach, visualization/graphical methods (e.g. MARAS flower)
  - Environmental: PEF aggregation approach (weighted sum and external normalization), visualization/graphical methods
  - Economic: CE-LCC aggregation approach, visualization/graphical methods
  - Social: UNEP / PSILCA DB aggregation approach
- CE&LCSA integration / visualization approaches:
  Graphical integration approach

2.3.4. KPIs

The following bullet list reports a set of KPIs to be measured in the DIS use case. The intent of these KPIs is just validating in a real context some of the most relevant performances related with circular procedures. Hence, this list represents just a subset of the KPIs already identified in D3.4 (reporting specific eco-design measures) and D2.2 (reporting specific evaluation procedures). In order to allow a direct comparison, the same KPIs will be measured both in the AS IS (manual disassembly) and TO BE (semi-automated disassembly) scenarios:

- Recycling/recovery rates (in % and in mass) of total IMSE and individual materials/elements/compounds (at EoL)
- Technical feasibility for eco-design/recycling technology, physics based quantified recommendations for Eco-design (design for recycling)
- Exergetic performance [MJ/h or kW]
- Energy consumption [kW]

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- Economic performance [€]:
    - Personnel cost
    - Energy cost
    - Purchasing cost
    - R&D cost
- Environmental performance, e.g. PEF indicators for (at least 2) scenario's, including incineration and recycling
- Social performance, e.g.:

    Consumers:
    - Violations of mandatory health and safety standards [Yes/No]
    - Is the product included with health and safety labels? [Yes/No]
    - Do you hold a certification/label for your products or plant on privacy assurance? [Yes/No]

    Local community:
    - Level of industrial water use
    - Extraction of biomass
    - Extraction of fossil fuels
    - Extraction of industrial and construction minerals
    - Extraction of ores
    - Indicate management effort [€] to minimize use of hazardous substances in the product and in the definition of production process
    - % of suppliers based locally (100 km)

    Workers:
    - Establishing sufficient safety measures for workers
- Circularity performance:
    - Thermodynamic rarity indicator
    - Recycling index
    - CFF
    - Quality of the recycled materials from IMSE applications (% of purity or kg)

Figure 6 – The ECO use case description table

Objective: • IMSE eco-design	**Owner & contributors:** • **TNO** • WALTER • TXT • MARAS • SEAT • EUROLCDS	**Expected impacts:** • Improve processes • Facilitate dismantling • Reduce env. impacts

Validation targets: Power consumption, material usage, reduced/reused/recycled waste from production; Transparency of recycled plastics; Conductivity (if applies); (Thermo-)mechanical properties	Evaluation procedures: Circularity assessment; Environmental assessment; Economic assessment; Social assessment; CE&LCSA aggregation approaches; CE&LCSA integration / visualization approaches
Activities: Train WALTER, EUROLCDs and SEAT researchers on: A) how in mold/structural electronics can be exploited in new automotive applications, B) green printed electronics production processes and materials; Compare green in-mold/structural electronics production process performances with current ones in terms of circularity levels, by exploiting TREASURE platform's potentialities; Assess different production processes according to guidelines established in WP4; Validate circularity performances through established KPIs.	KPIs: Recycling/recovery rates of total IMSE and individual materials/elements/compounds (at EoL); Technical feasibility for eco-design/recycling technology physics based quantified recommendations for Eco-design (design for recycling); Economic performance; Environmental performance; Social performance; Circularity performance

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4. Conclusions & next steps

The present deliverable (D1.4) integrates and improve information already presented in D1.3 that will be implemented within the different use cases. The document has been developed to define a clear logical picture of the industrial use cases, identifying all the requirements to be used as input by WP5 and WP6 activities.

To drives these outcomes, a detailed use case analysis has been performed, together with T1.2, defining the platform's requirements and functionalities that are supposed to enhance the transition towards the TO-BE status (documented in D1.2).

The next steps will mainly flow into WP5 and WP6, addressing the lab-scaled development and optimization of the pilots and their validation & demonstration together with the TREASURE industrial partners. The activities will be carries out strongly collaborating with the other WPs, mainly WP5 for testing activities, and WP6 for the final validation of the TREASURE pilots.

5. Abbreviations

AHP	Analytical Hierarchy Process
BoL	Beginning of Life
CCI	Circular Car Initiative
CE	Circular Economy
CE&LCSA	Circular Economy & Life Cycle Sustainability Analysis
CFF	Circular Footprint Formula
cLCC	Cost breakdown structure Life Cycle Costing
eLCC	Externalities' Life Cycle Costing
ELV	End-of-Life Vehicle
EoL	End of Life
I4.0	Industry 4.0
IMSE	In-Mold/Structural Electronics
ITO	Indium Tin Oxide
KET	Key Enabling Technology
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
LCD	Liquid Crystal Display
MCI	Material Circularity Index
MCDA	Multi-Criteria Decision Analysis
PCB	Printed Circuit Board
PCI	Product Circularity Index
PEF	Product Environmental Footprint
PET	PolyEthylene Terephthalate
RI	Recyclability Index
SLCA	Social Life Cycle Assessment
SMD	Surface-Mounted Device