WRS2024 MILAN

TOWARDS SMART AND ADVANCED REMANUFACTURING FOR A SUSTAINABLE FUTURE

Bridging the Gap between Science and Industry

REMANUFACTURING OF ELECTRONIC CONTROL UNITS FOR OFF-ROAD VEHICLES: PROCESS ANALYSIS AND ENVIRONMENTAL ASSESSMENT

World Remanufacturing Summit 2024

Aula Magna “Carassa Dadda” Politecnico di Milano – 13th March 2024

Presenter: **Livia Nastasi**

Department of Engineering for Environment, Land and Infrastructure (DIATI) - Politecnico di Torino, Italy

Politecnico di Torino

UNIONE EUROPEA Fondo Sociale Europeo

PON Ricerca e Innovazione

REACT EU

POLITECNICO MILANO 1863

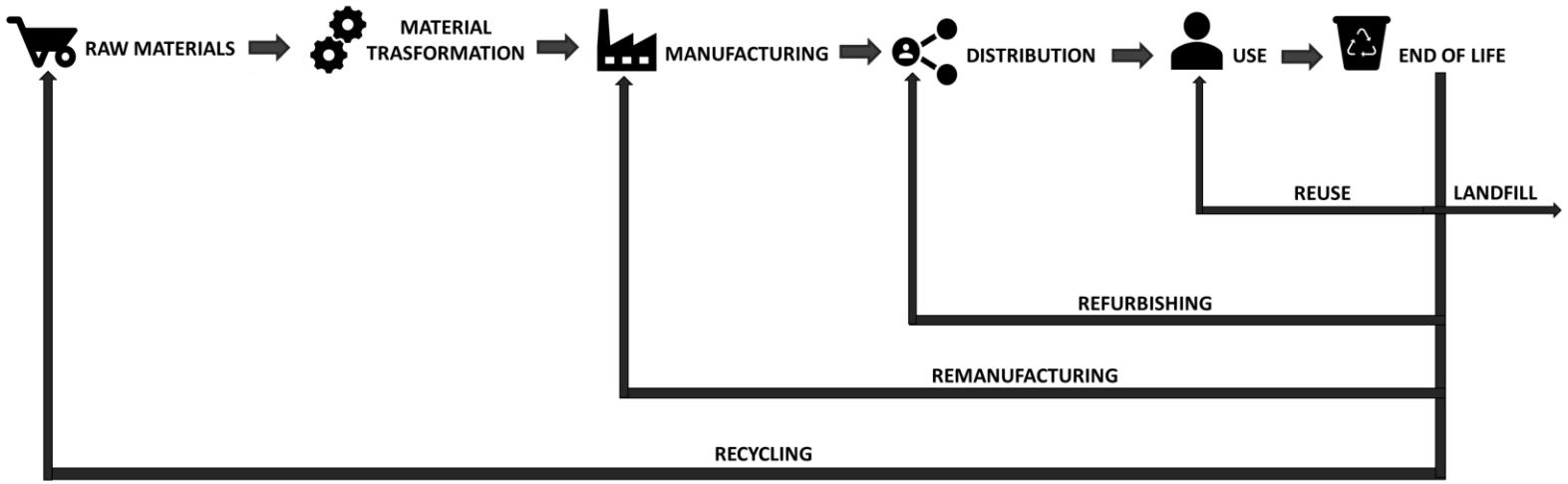
mecc

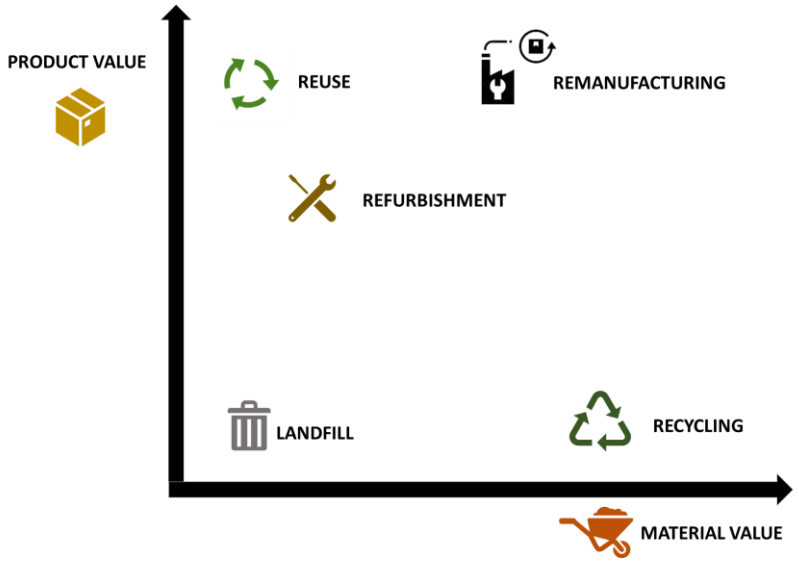
Regione Lombardia

apra europe

Remanufacturing: a key circular economy strategy

Remanufacturing: "return a used product to at least its original performance with a warranty that is equivalent or better than that of the newly manufactured product" (British Standards Institution, 2009)





Electronic control units

Electronic control unit (ECU) is an embedded system in vehicles electronics that controls one or more of the electrical systems or subsystems in the vehicle.

Small size machines

Number of ECUs: about 5
Types:

- Engine control unit
- Mechanical drive unit
- Antilock braking system (ABS)
- Air conditioning
- DE NOx

Medium/Large size machines

Number of ECUs: about 10
Types:

- Engine control unit
- Transmission (PCM)
- Park lock
- Air conditioning
- Joystick
- ISO-BUS system (TECU)
- Display
- Braking system
- Body controls
- DE NOx

WHY REMAN?

- High valuable materials
- Resources and energy recovery
- Less price
- Less machine downtime
- Same performance as new
- Warranty as new

REMAN ECUs investigation: Aims and Methodology

Goal: investigation of the remanufacturing process performed by a case study company on three different types of electronic control units used in CNH Industrial's off-road vehicles

ECUs selection

Three representative ECUs were selected:

- Engine control unit
- Display
- Joystick

For each type, were analyzed 5 samples.

ECUs characterization

The three ECUs were characterized as follows:

- Disassembly
- Components classification
- Weighing

ECUs remanufacturing data collection

Information and data about ECUs' remanufacturing process were collected through:

- Interviews
- On-site specifications
- Direct measurements
- Technical documents

ECUs assessment

For the three remanufacturing processes were performed the environmental assessment

ECUs selection

Engine control unit

Source: image taken from our investigation

Joystick

Source: image taken from our investigation

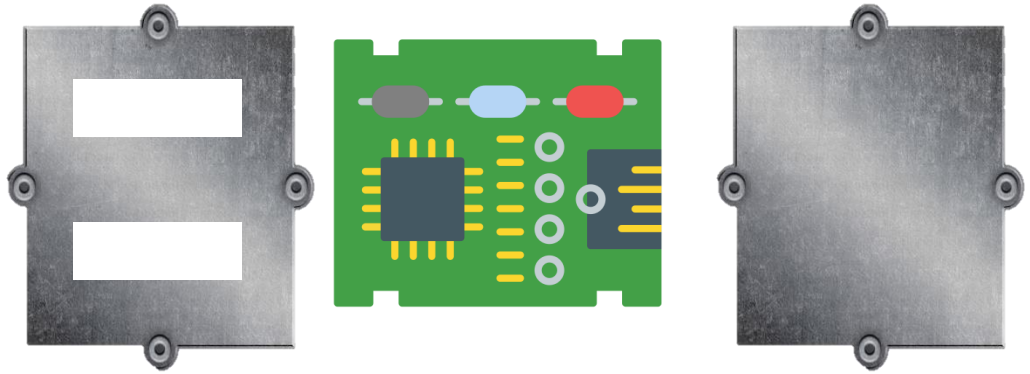
Display

Source: image taken from our investigation

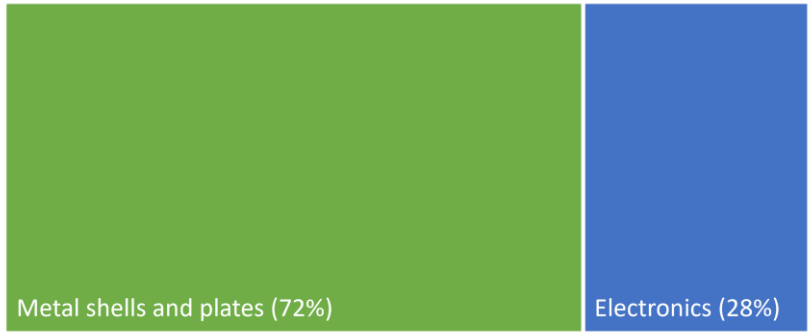
Engine control unit: components and remanufacturing process

The main components of engine control units are:

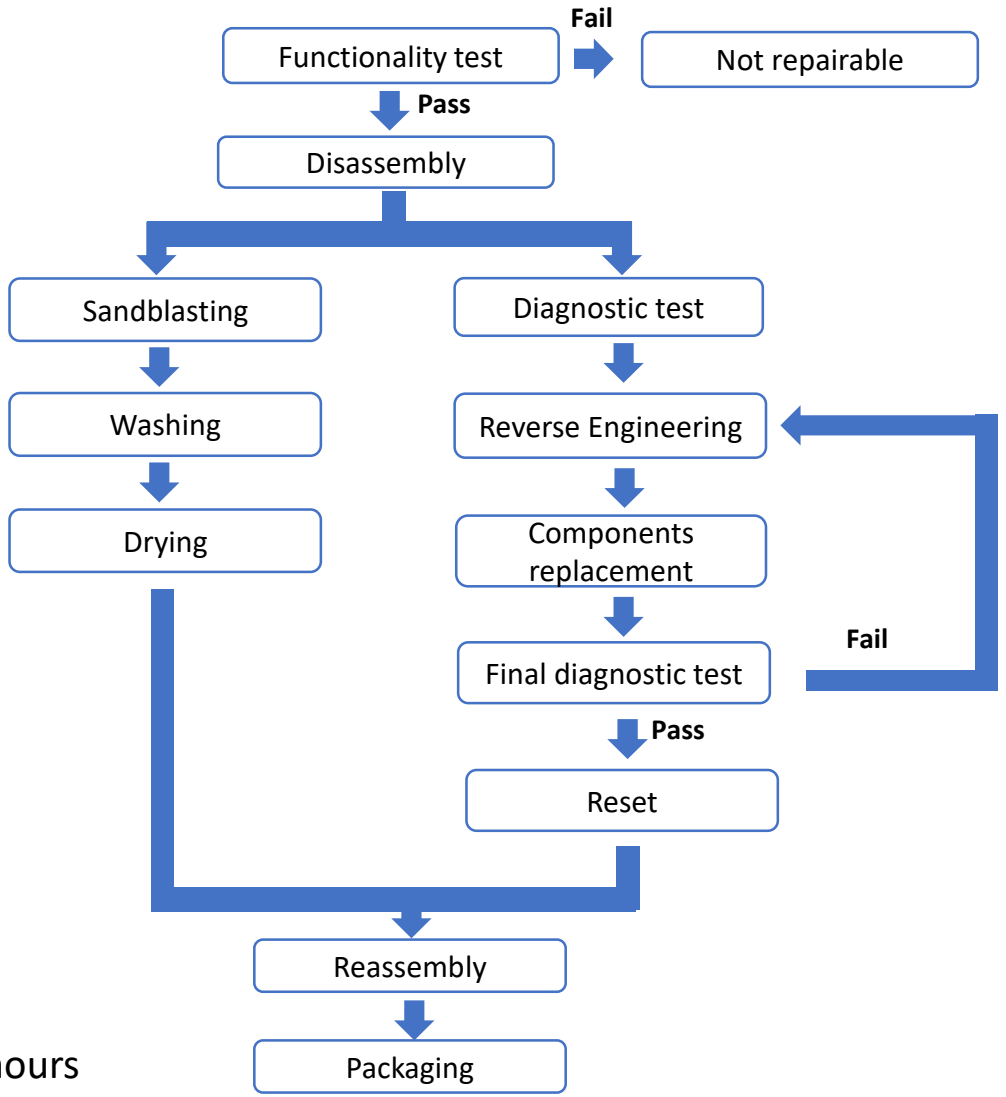
- Metal shells & plates
- Electronic components (e.g., PCB, transitors, integrated circuits)



Engine control unit composition



Remanufacturing process



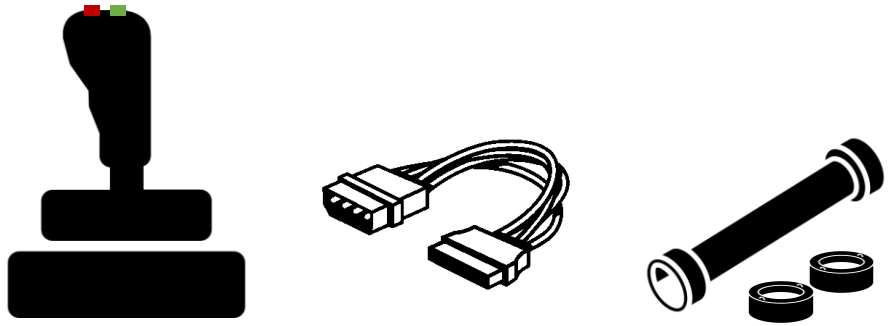
Total average weight: 1.6 Kg

Average duration of the process: 3.13 hours

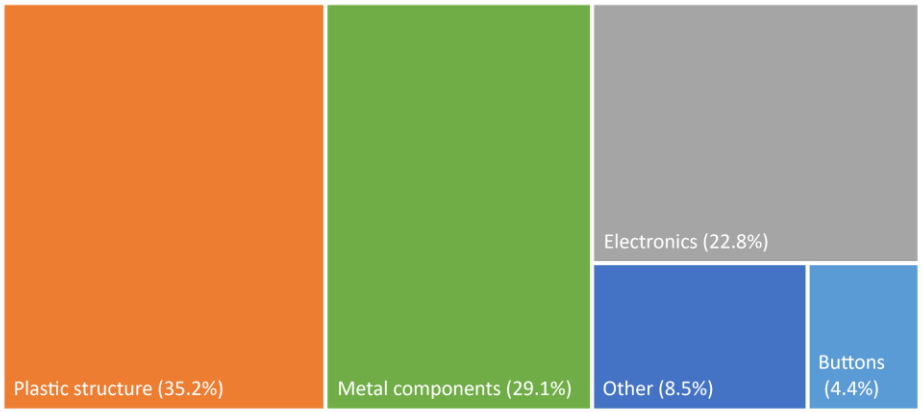
Joystick: components and remanufacturing process

The main components of joysticks are:

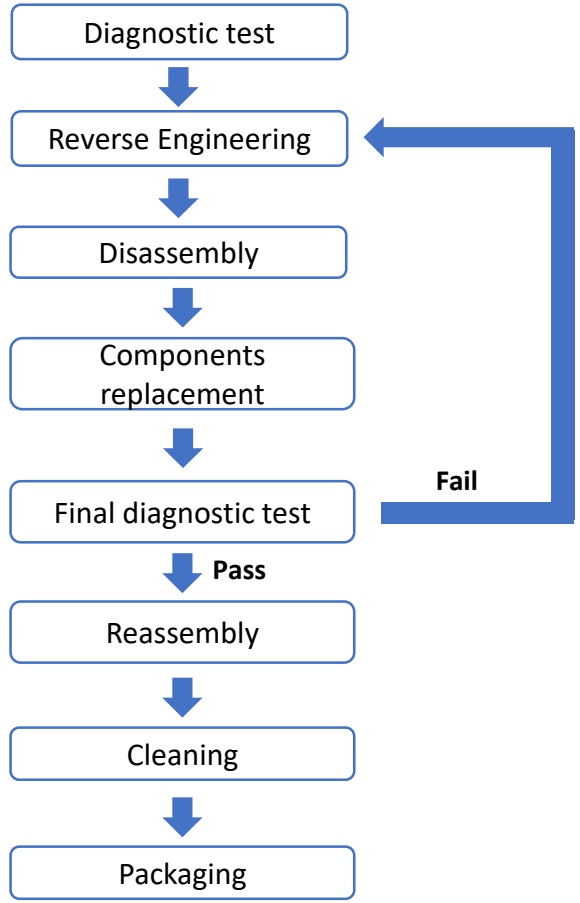
- Plastic structure
- Buttons
- Electronic components (e.g., cables)
- Metal components



Joystick composition



Remanufacturing process



Total average weight: 277 g

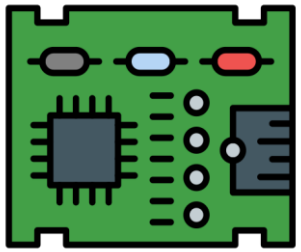
Average duration of the process: 47 minutes

Display: components and remanufacturing process

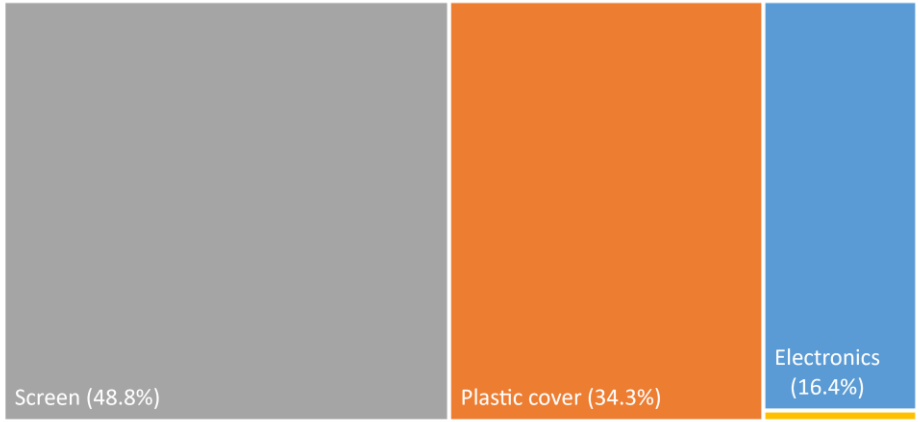
The main components of displays are:

- Plastic cover
- Screen (LCD + Touch screen)
- Electronic components (e.g., Printed Circuit Board, capacitors)





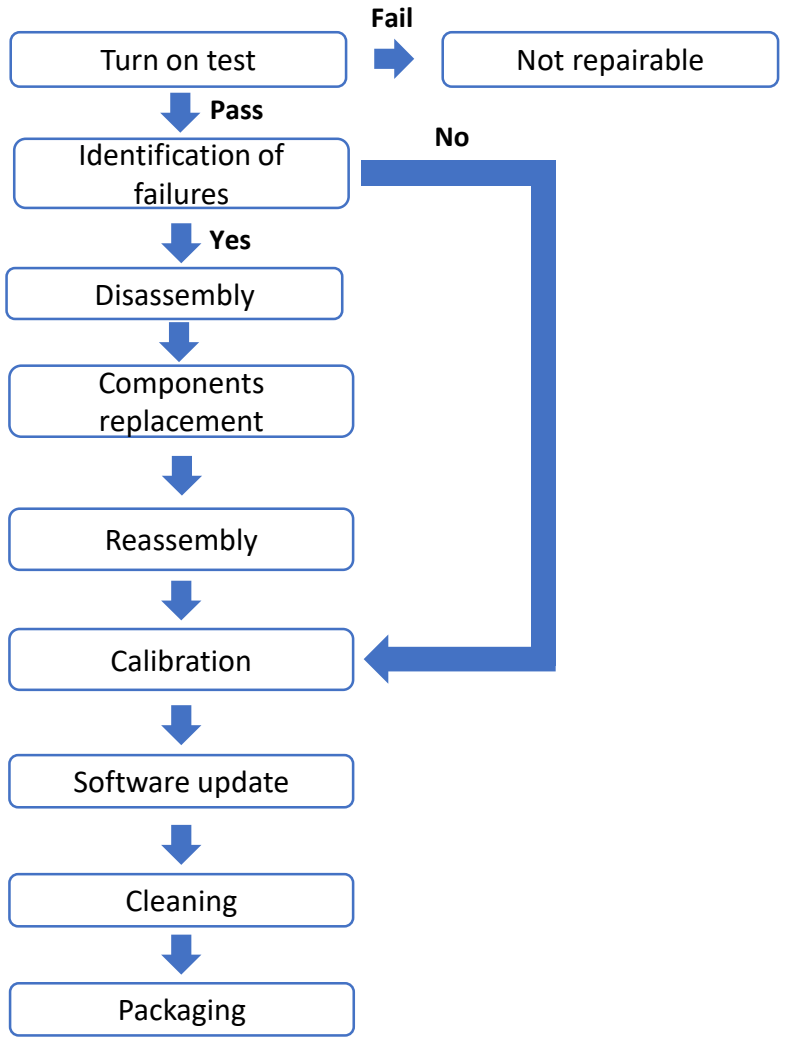

Display composition



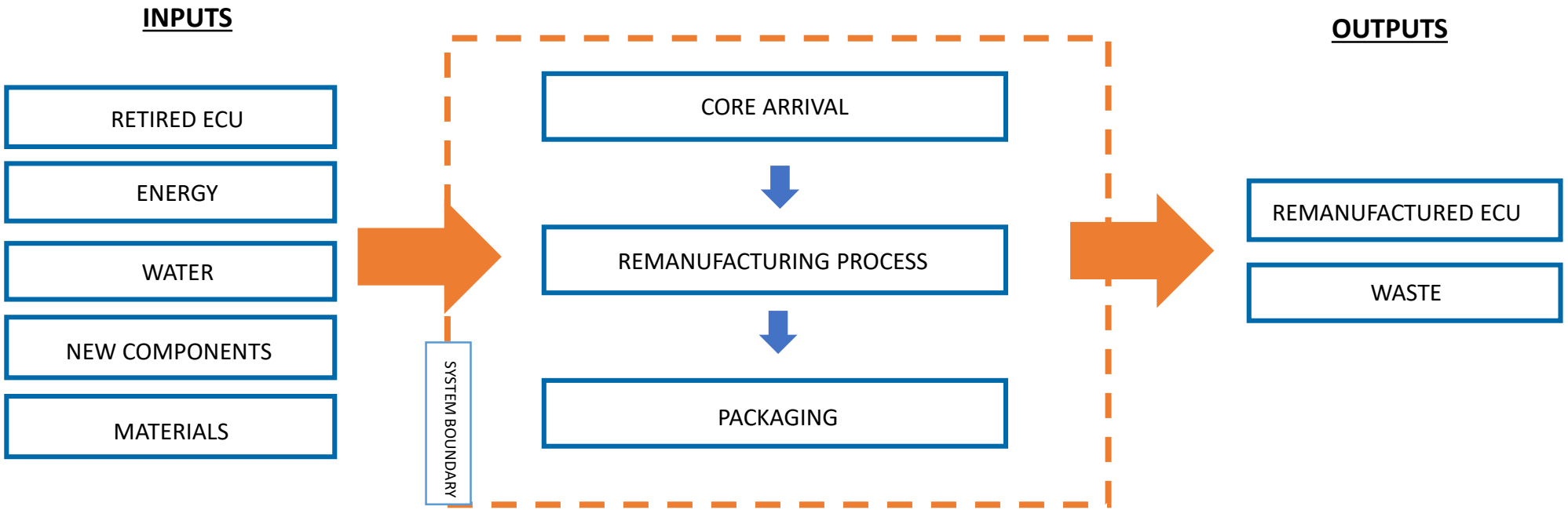
Total average weight: 1.3 Kg

Average duration of the process: 29 minutes

Remanufacturing process



Remanufacturing process: environmental assessment



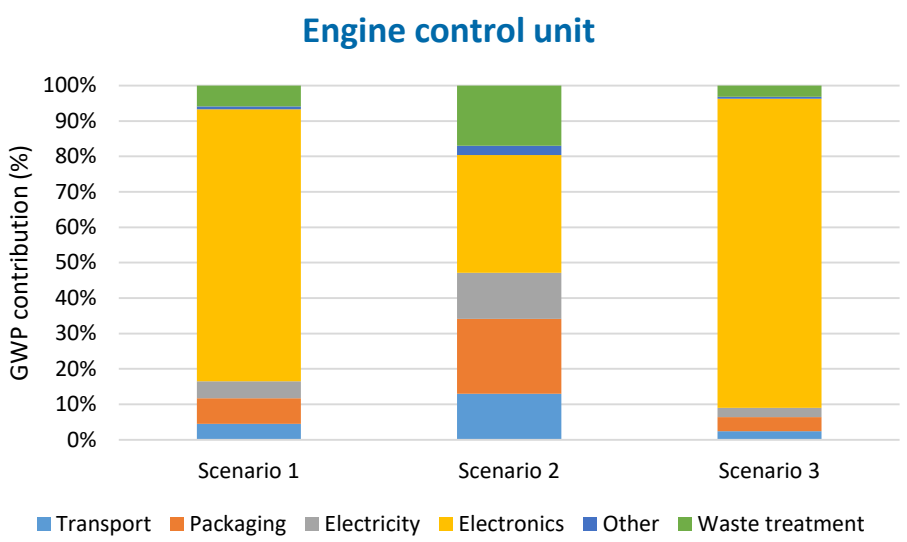
Functional unit: remanufacturing of a single end of life ECU used in agricultural machinery

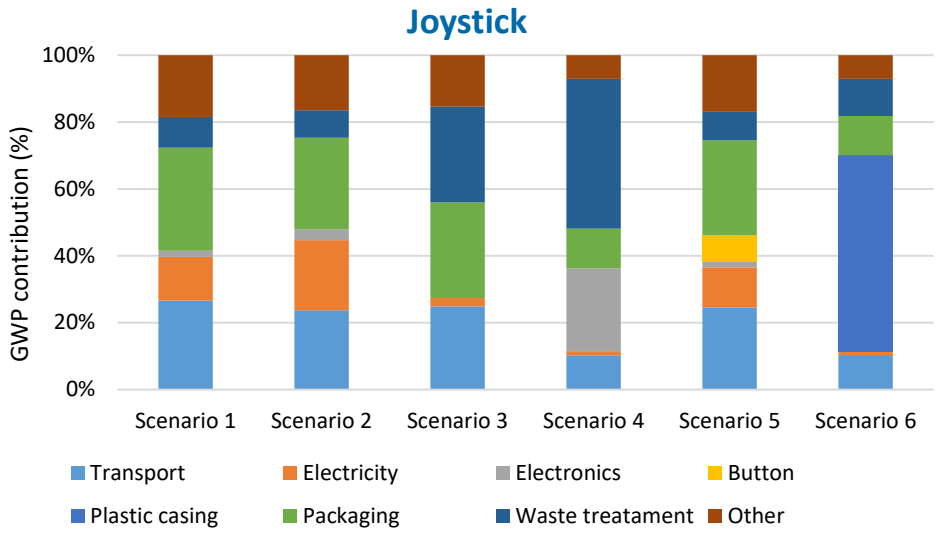
Impact category: Climate Change - Global Warming Potential ($KgCO_2eq/FU$)

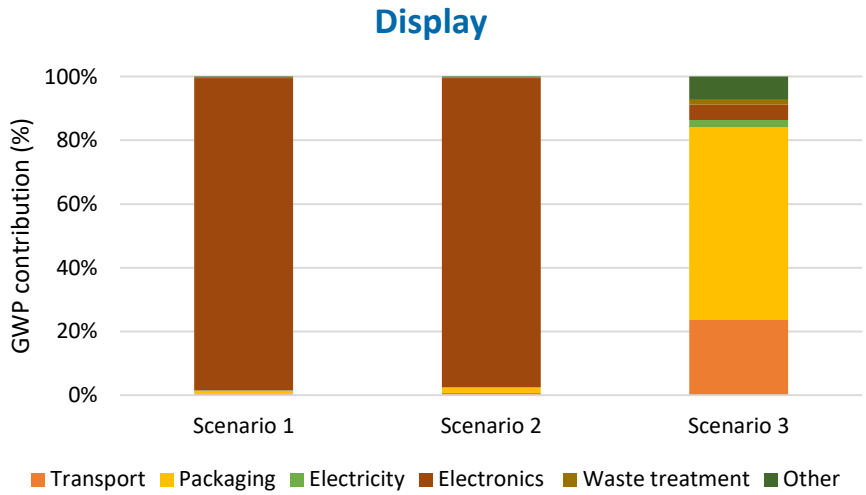
Data source: CNH Industrial and remanufacturing case study company

Background data: Ecoinvent 3.9.1 database, Product Environmental Footprint 2022 database and relevant literature

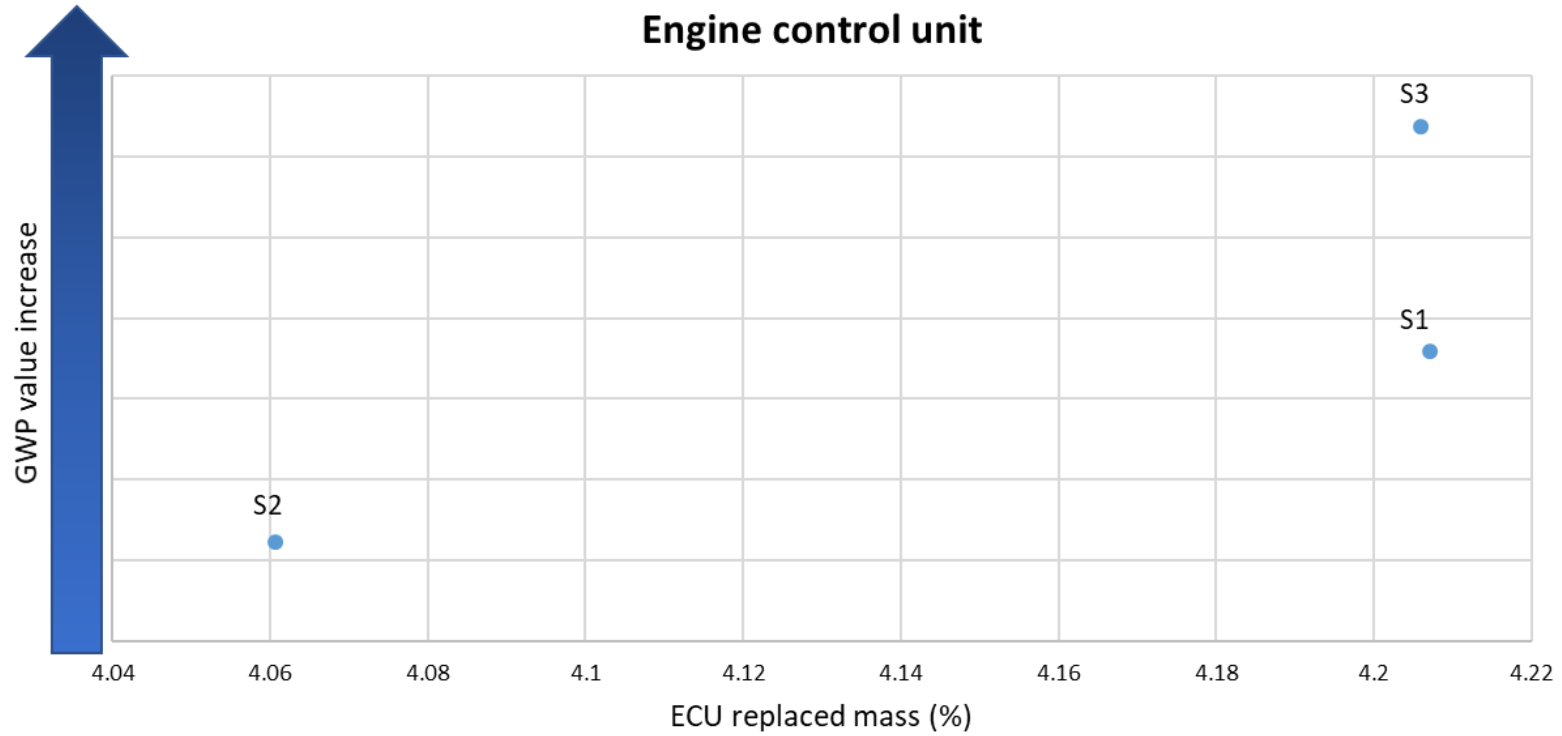
Remanufacturing process: environmental assessment





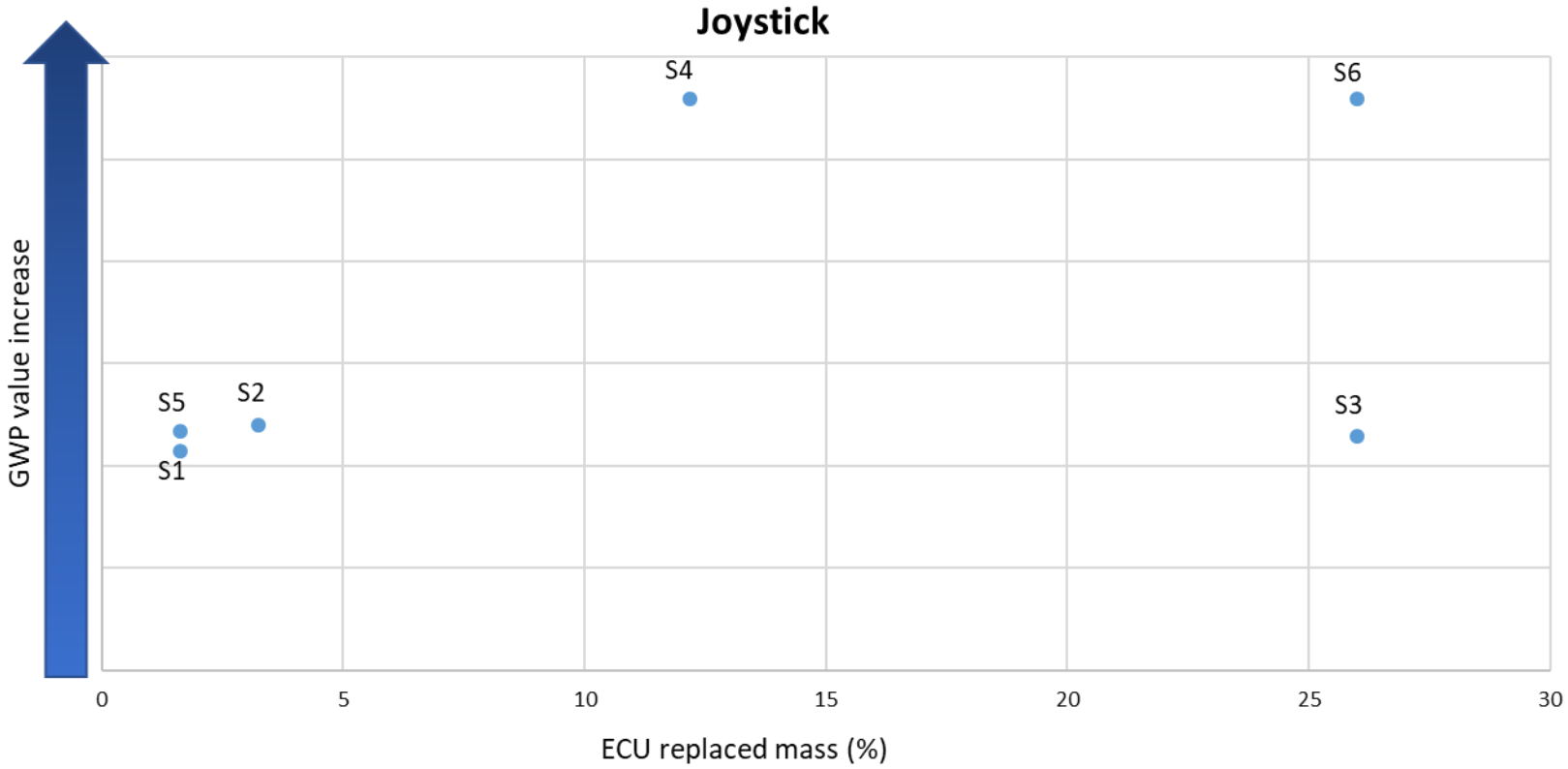


Remanufacturing process: environmental assessment



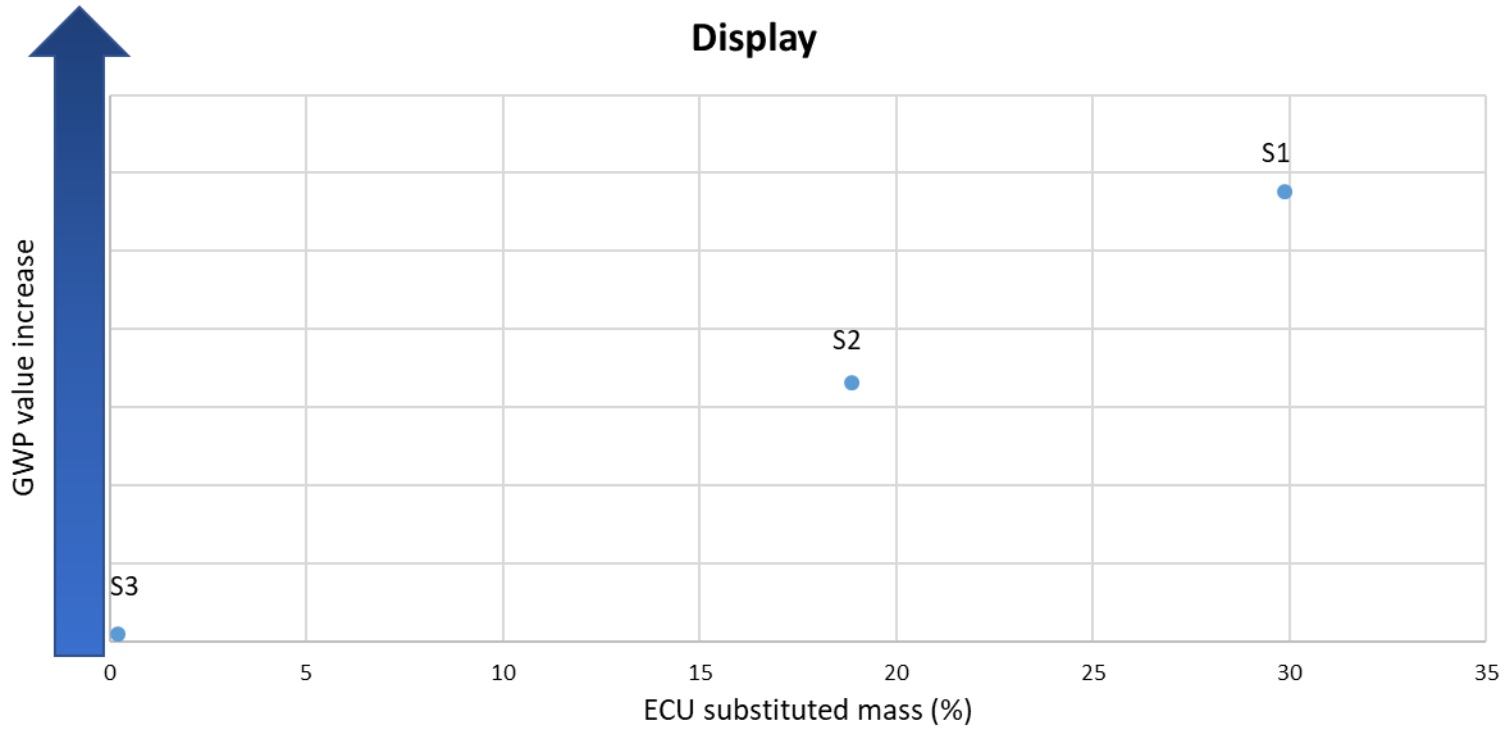
Average total ECU retained original mass: 95.8%
Average total ECU replaced mass: 4.2%

Remanufacturing process: environmental assessment



Average total ECU retained original mass: 88.3%
Average total ECU replaced mass: 11.7%

Remanufacturing process: environmental assessment



Average total ECU original retained mass: 83.3%
Average total ECU replaced mass: 16.7%

Conclusions

The key outcomes of the performed analysis highlighted that:

- Remanufacturing is a key circular strategy to extend the lifecycle of electronic control units
- The remanufacturing process is different for each type of control unit
- Remanufacturing performed on electronic control units allows to retain most of their original mass
- The resulting Global Warming Potential is highly affected by the type of replaced components