Pre-commercial pilot for the efficient recovery of Precious Metals from European end- of-life resources with novel low-cost technologies

THE USE OF DEEP EUTECTIC SOLVENTS AND IONIC LIQUIDS IN PEACOC

11TH MAY 2022

The project has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement N° 958302

Outline

- PEACOC project overview
  - Background (incl. Importance of PMs, challenges in recycling PMs)
  - Objectives
  - PEACOC Consortium
  - Technologies in PEACOC

- The use of DES and ILs in PEACOC
  - DES for the recovery of PGMs, Ag and Au
  - DES for the separation of PMs mixtures into single PMs streams

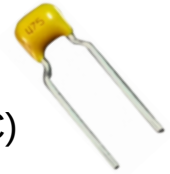
PEACOC Background

November 2016 – April 2021 **TRL4-5**

Recovery of PGMs (**Pd**, **Pt** and **Rh**) from:

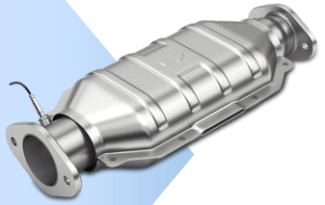
Ni and Cu smelter tailings and slags

Spent autocatalysts



Electronic waste (MLCC)

May 2021 – April 2025 **TRL7**



Spent AUTOCATALYSTS

Pd Pt Rh

EoL PV PANELS

Ag

Low-grade and mid-grade PCBAs

Au Sn Pd

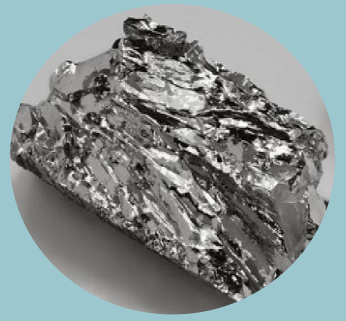
Importance of Precious Metals and PGMs

Target Precious Metals within PEACOC project:

Platinum (Pt)

Palladium (Pd)

Rhodium (Rh)



Platinum Group Metals (PGMs)

Gold (Au)

Silver (Ag)

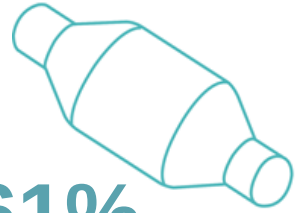
Are irreplaceable industrial commodities due to their **unique physicochemical properties** (low corrosiveness, catalytic properties, low electrical resistivity, etc.)

EU´s economy is **highly dependent** on the import of several PMs

Considerable amounts of PMs are available in EoL products in EU, with a vast potential to be recycled

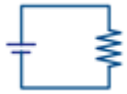
Importance of Precious Metals and PGMs – Key facts

→ PGMs



61%
Autocatalysts

12%
Jewelry



8%
Electrical

- **Europe is the world's largest consumer of PGMs - Autocatalysts production** (~ 90%, 54% and 80% of Pd, Pt and Rh, respectively.
- **The primary production of PGMs in the EU is insignificant (**~85% of the primary supply comes from South Africa and Russia).
- The **recycling input rate of EoL products containing PGMs** in Europe is estimated at 21% largely **insufficient to meet the EU demand**.

→ GOLD

- **EU production accounts for <1% of the global primary Au production.**
- **WEEE offers an important recycling potential** (i.e., 20 to 100g Au/t), **but also represents a challenge,** especially from low-mid grade PCBA.

→ SILVER

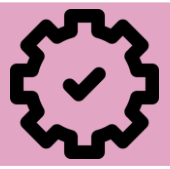
- **EU accounted for ~7% of the global Ag primary production.**
- **Vast potential for Ag recycling from PCBA and EoL solar panels in EU.**

Challenges in recycling Precious Metals and PGMs

The **current industrial recycling technologies** such as smelting or hydrometallurgical processes **present several limitations**


CAPEX-OPEX intensive


High Temperature (>1200°C)


Limited efficiency of recovery due to the complex mixture of materials in *end-of-life* products e.g., low-mid grade PCBA (i.e., 20 to 100g Au/t)


High environmental footprint resulting from the use of strong acidic solutions


Adverse impacts on both human health and environment


The *large-scale* nature of the *state-of-the-art* refineries prevents the development of SME-scaled operations

Objectives

PEACOC Objective

To demonstrate a first-of-a-kind economically and environmentally-viable pre-commercial metallurgical system for recovering precious metals from a wide variety of abundant *end-of-life* products in Europe.

The specific objectives of the PEACOC project are:

Improve the **precious metals concentration** stage by up to **100 times**

Aim at **near zero-waste strategy** by valorizing the recovered precious metals and residues into new functional products

Design and operate a **mobile refining pilot at pre-commercial scale** for producing precious metals with > **99% purity** at gross **profit margin up to 80%**

Expand the impact of the PEACOC project by conceptually exploring the **replication of the proposed process to treat other end-of-life products**

Prove the PEACOC **sustainability from economic, technical and environmental** perspectives

Identify new or un-valorized resources in Europe and neighboring countries to increase the recycling input rate

PEACOC Consortium

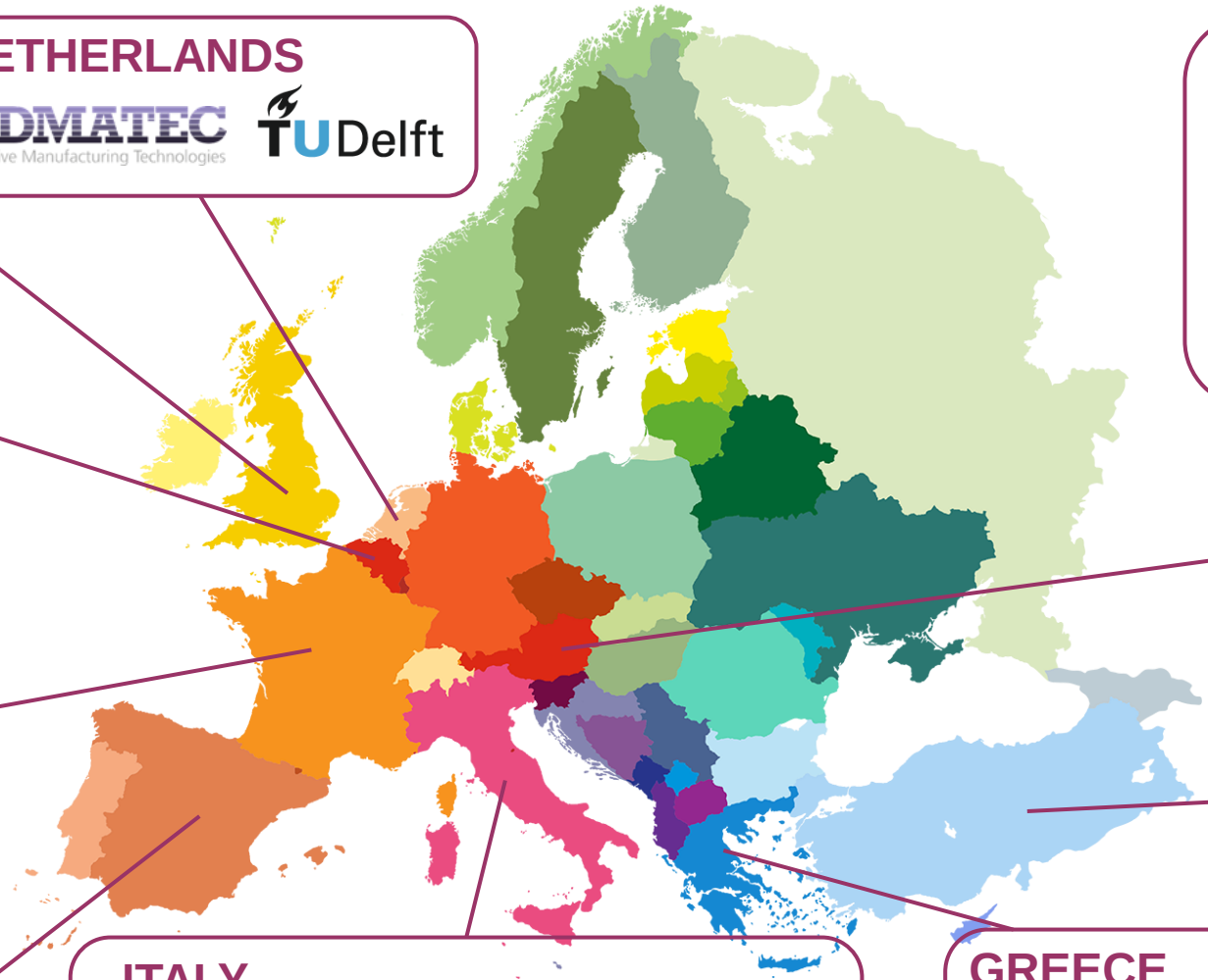
UK
JM

NETHERLANDS
ADMATEC Additive Manufacturing Technologies
TU Delft

BELGIUM
vito
comet traitements
LIÈGE université
PNO

FRANCE
6TMIC Manufacturing solution using advanced engineering

SPAIN
tecnalia MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE
ceinnmat Emerging technologies



ITALY
CRF
CENTRO RICERCHE FIAT
UNIVERSITÀ DEGLI STUDI DE L'AQUILA
MBN nanomaterialia
Treee

- ✓ ***19*** Partners
- ✓ ***8*** Countries (+ UK and Turkey)
- ✓ ***12.838.997,50 €*** Budget
- ✓ From ***01.05.2021*** to ***30.04.2025***
- ✓ H2020, Innovation Action

AUSTRIA
ISL

TURKEY
Ford FORD OTOSAN
istaç

GREECE
3D HUB GREECE
MONOLITHOS CATALYSTS - RECYCLING - INNOVATION

Technologies in PEACOC projects

Pre-treatment and concentration WP3

EoL Autocatalysts

MONOLITHOS CATALYSTS - RECYCLING - INNOVATION

Flotation

LIÈGE université

Deep Eutectic Solvent

tecnalia

Low/Medium grade EoL PCBA

Treee

NOVA

LIÈGE université

Ultra-Fast Sorting

TU Delft

Magnetic Density Separation

TU Delft

Magnetic Density Separation

TU Delft

NOVA

LIÈGE université

Ultra-Fast Sorting

TU Delft

EoL PV panels

cometraitements

Magnetic Density Separation

TU Delft

Refining

Microwave-Assisted Leaching

vito

ceinnmat Emerging technologies

Gas-diffusion Electrocrystallization

vito

6TMIC Manufacturing solution using advanced engineering

JM

Precious metals

Residues

Valorization WP8

Mechanical Alloying

MBN nanomaterialia

Powder composites

Extrusion

3D HUB GREECE

Filaments for 3D printing

3D printing

ADMATEC Additive Manufacturing Technologies

3D-printed items: jewelry, catalysts and PCBs

Manufacture of autocatalysts and fuel cells

CRF CENTRO RICERCHE FIAT

Ford FORD OTOSAN

MONOLITHOS CATALYSTS - RECYCLING - INNOVATION

vito

Autocatalysts and Hydrogen fuel cells

Deep Eutectic Solvent

tecnalia

Single Precious Metals

The use of DES and ILs in PEACOC

Within PEACOC DES will be used mainly for:

- To **selectively extract PGMs** from the pre-concentrated autocatalyst sample
- To valorise PMs streams, i.e., **mixtures containing PGMs, Ag and/or Au**, from the refining process **into single PMs streams**
- To valorise residues from the concentration and the refining stage aiming at **near-zero-waste strategy**

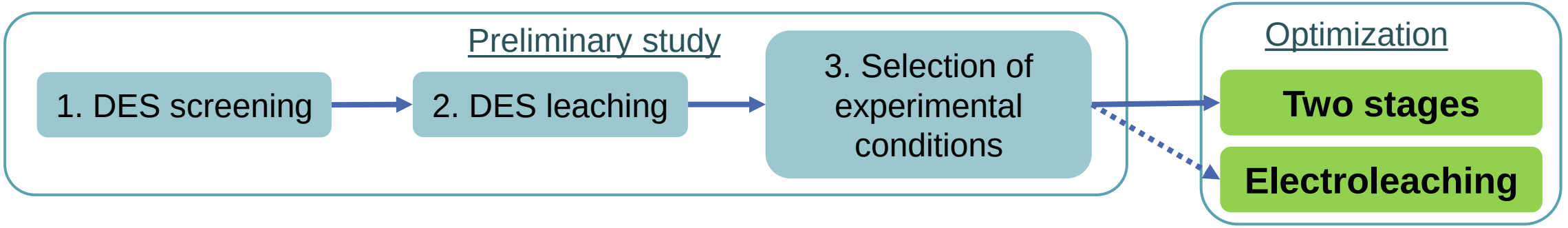
DES PROCESS WITHIN PEACOC AIMS TO

→ TO MAXIMIZE THE EXTRACTION OF PMs OUT FROM THE RESIDUE – **OPTIMISE EFFICIENCY**

→ TO TARGET EXTRACTION OF SPECIFIC METALS **– OPTIMISE SELECTIVITY**

→ TO SEPARATE MIXTURES OF PGMs INTO SINGLE PGMs STREAMS – **ADDED VALUE**

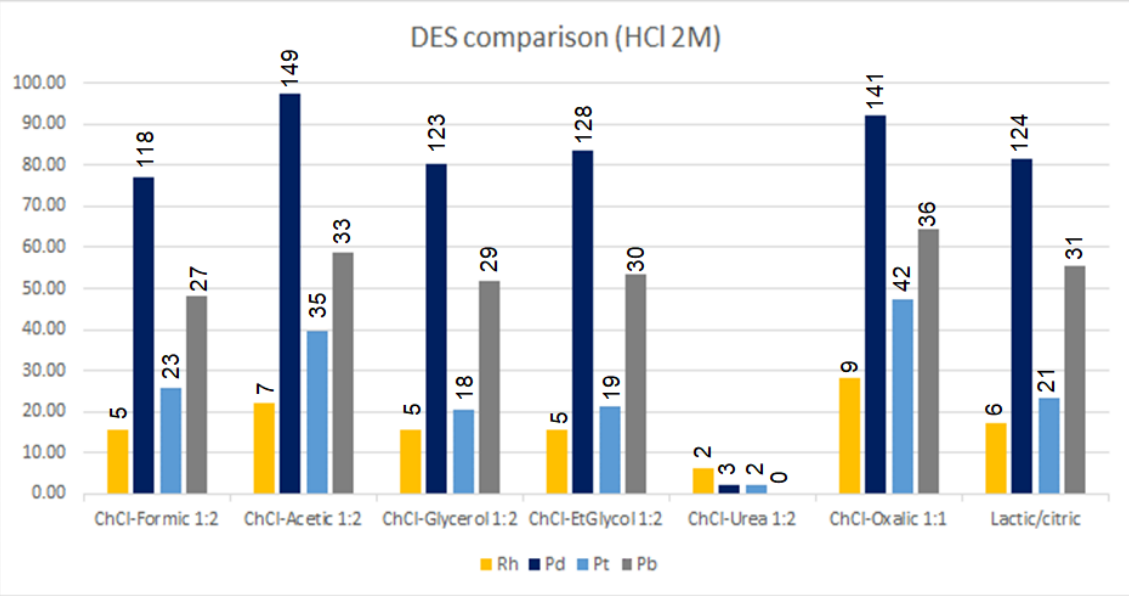
EXPERIMENTAL PROCEDURE



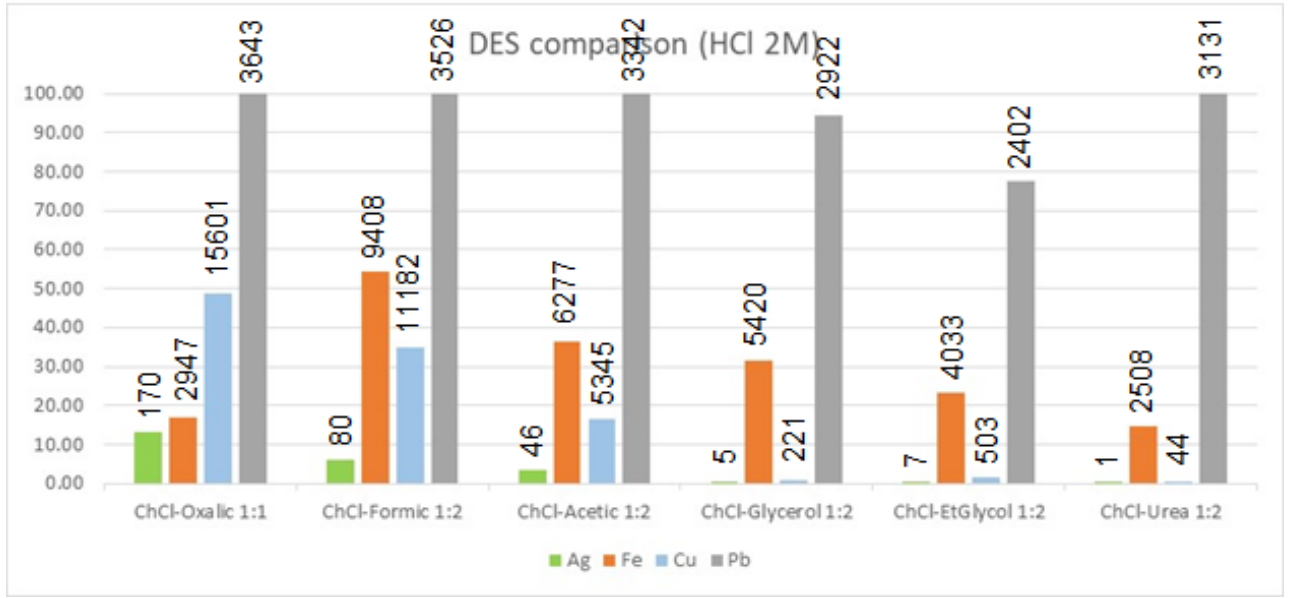
The use of DES and ILs in PEACOC

→ TO EXTRACT PRECIOUS METALS OUT FROM THE RESIDUE

Autocatalyst stream (PGMs)



PV scrap stream (Ag)



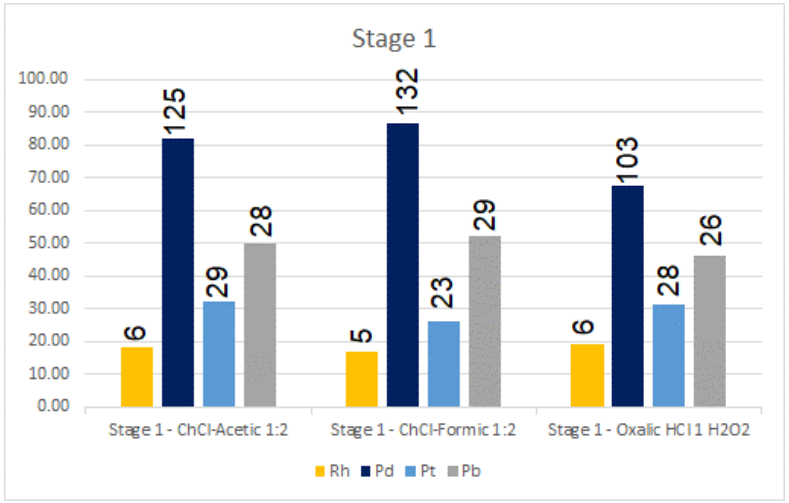
- The **effect of different additives** (H2O2, HCl, HNO3, H2SO4, etc) and **operational conditions** (time, temperature) were studied.
- Same DES to extract the same metals from different matrices under the same operational conditions **will not perform the same** (effect of impurities, oxidation state of the metal, crystallography, etc).
- Combination of different experimental conditions in **multiple-stage leaching processes** can be used as an **strategy to separate and selectively extract specific metals** from the sample (**combination with electrochemical processes**).

The use of DES and ILs in PEACOC

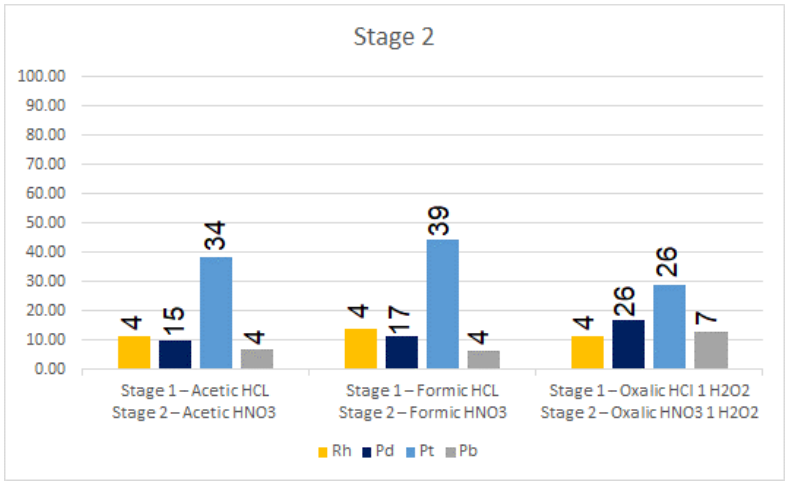
→ TO SEPARATE MIXTURES OF PMs INTO SINGLE PMs STREAMS

Autocatalyst stream (PGMs)

Stage 1 – Pd

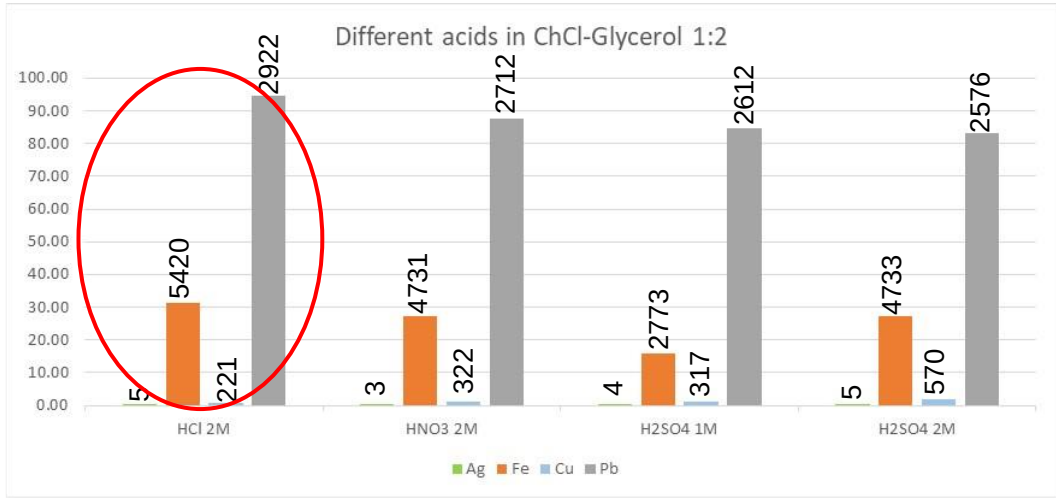


Stage 2 – Pt

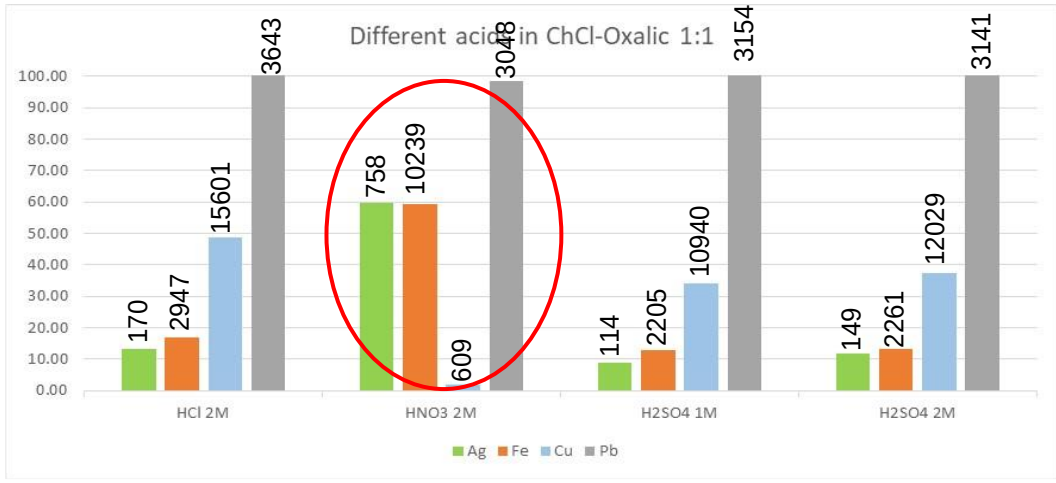


PV scrap stream (Ag) (in process)

Stage 1 – Fe and Cu (impurities)



Stage 2 – Ag



Get in touch!

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Thank you

MAY 2022

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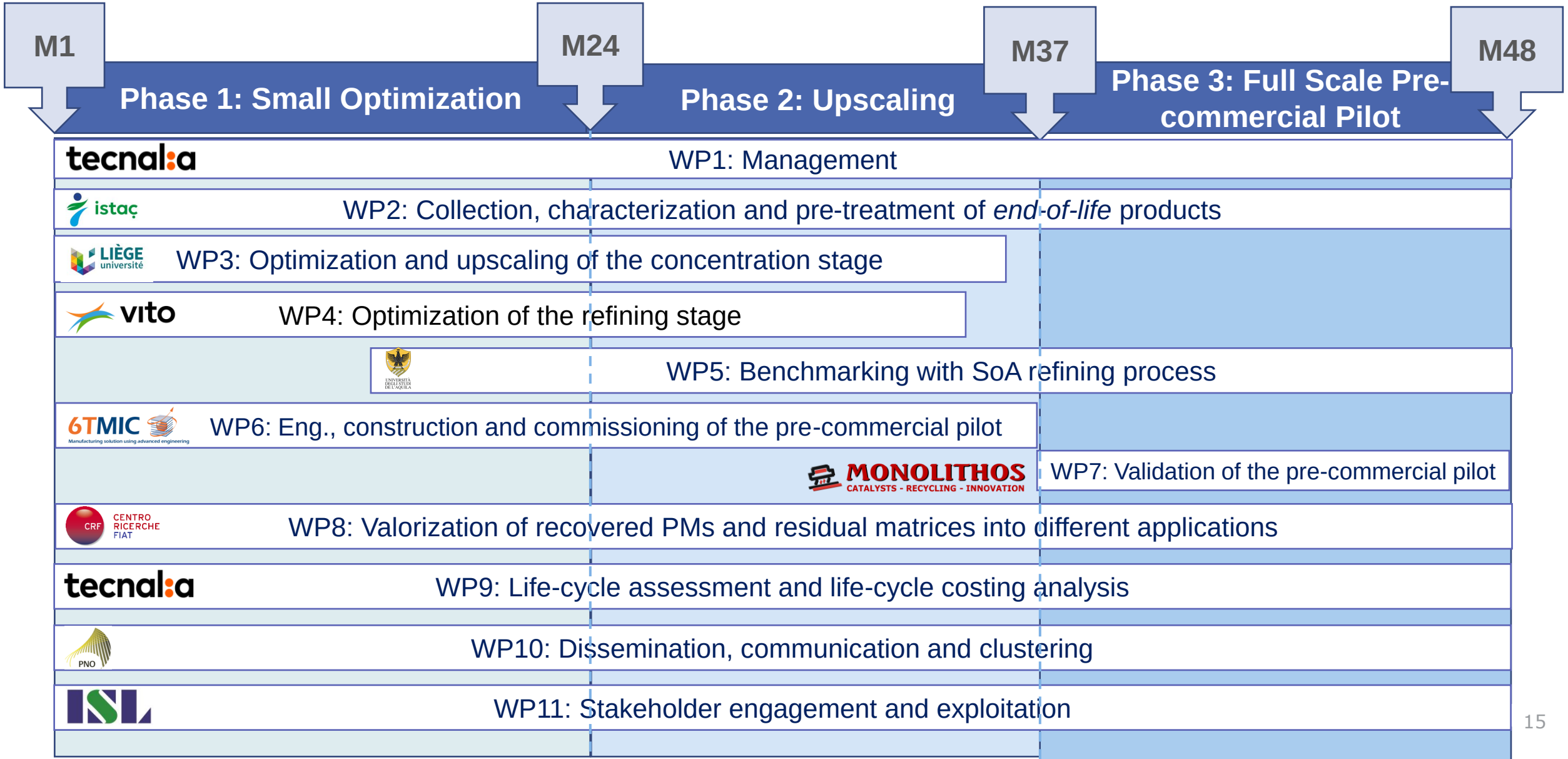
Work plan


M1
M24
M37
M48
Phase 1: Small Optimization
Phase 2: Upscaling
Phase 3: Full Scale Pre-commercial Pilot
WP1: Management
WP2: Collection, characterization and pre-treatment of *end-of-life* products
WP3: Optimization and upscaling of the concentration stage
WP4: Optimization of the refining stage
WP5: Benchmarking with SoA refining process
WP6: Eng., construction and commissioning of the pre-commercial pilot
WP7: Validation of the pre-commercial pilot
WP8: Valorization of recovered PMs and residual matrices into different applications
WP9: Life-cycle assessment and life-cycle costing analysis
WP10: Dissemination, communication and clustering
WP11: Stakeholder engagement and exploitation

Expected Impacts

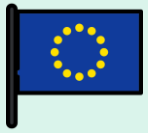
The specific impacts of the PEACOC project are:

To drastically reduce the supply risk of precious metals for Europe

To enable new business opportunities for SMEs interested in precious metals recycling and therefore unlock a significant volume of various secondary raw materials currently underexploited

To improve the profit margin, safety and environmental performances of large refineries with efficient and economically and environmentally friendly technologies

To consolidate the position of large industries (recycling companies, refineries, automotive, metallurgy) in Europe



To support the European Commission in reaching the ambitious energy and climate targets