Mineral Processing and Extractive Metallurgy
for Mining and Recycling Innovation Association

Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

The HydroWEEE strategy: a case study of efficient flexibility for the recovery of critical metals

UNIVERSITÀ POLITECNICA DELLE MARCHE

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EC Recycling Spin Off

THE FP7 PROJECTs

Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

SEVENTH FRAMEWORK PROGRAMME

Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries – HydroWEEE

2009-2012

and its follow up:

HydroWEEE-Demonstration

2012-2016

hydroWEEE

SEVENTH FRAMEWORK PROGRAMME

Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

9 partners from 4 countries

SMEs:

ISL – Kopacek KG (AT)

EcoRecycling (IT)

Greentronics (RO)

Relight (IT)

SET Recycling (RS)

RTD-Performers:

Institute Mihailo Pupin (RS)

INTER UNIVERSITY CENTER *HIGH TECH RECYCLING*

HTR

HIGH TECH RECYCLING
INTER-UNIVERSITY RESEARCH CENTER

hydroWEEE
Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

SEVENTH FRAMEWORK PROGRAMME

THE MAIN GOAL

To recover rare and precious metals from WEEE including lamps and spent batteries by hydrometallurgical processes

hydroWEEE

SEVENTH FRAMEWORK PROGRAMME

Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

keywords

simplicity

flexibility

feasibility in the premises of SME recyclers

the same plant used for different feed materials

availability of feed materials discontinuous during time

the same plant can be used by different SME recyclers

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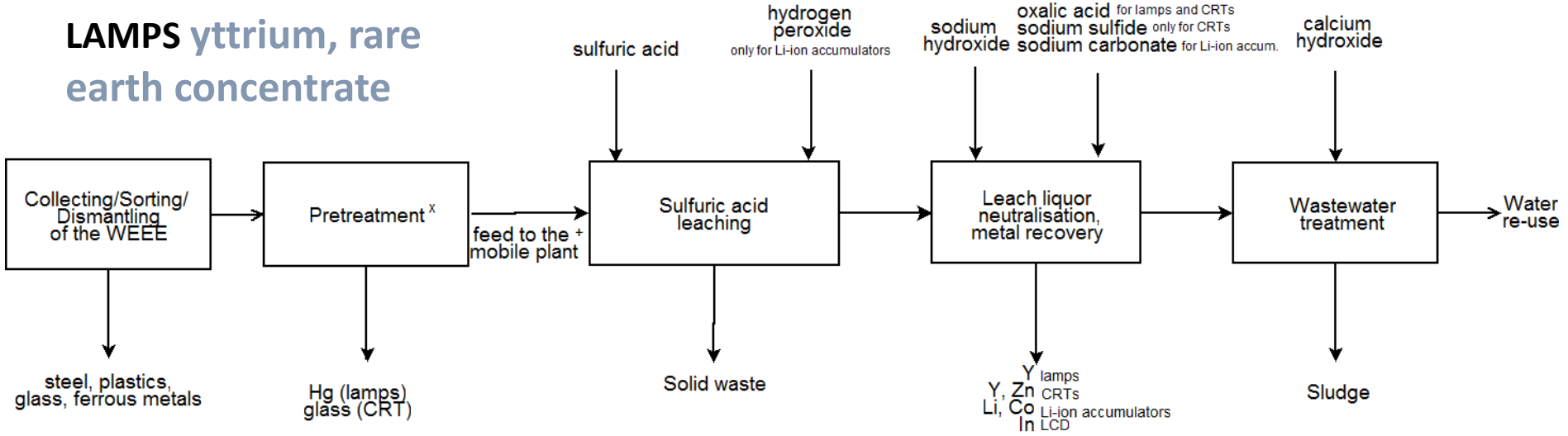
Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

LAMPS yttrium, rare earth concentrate

Li-ion accumulators cobalt, lithium



LCD indium

CRT yttrium, zinc, rare earth concentrate

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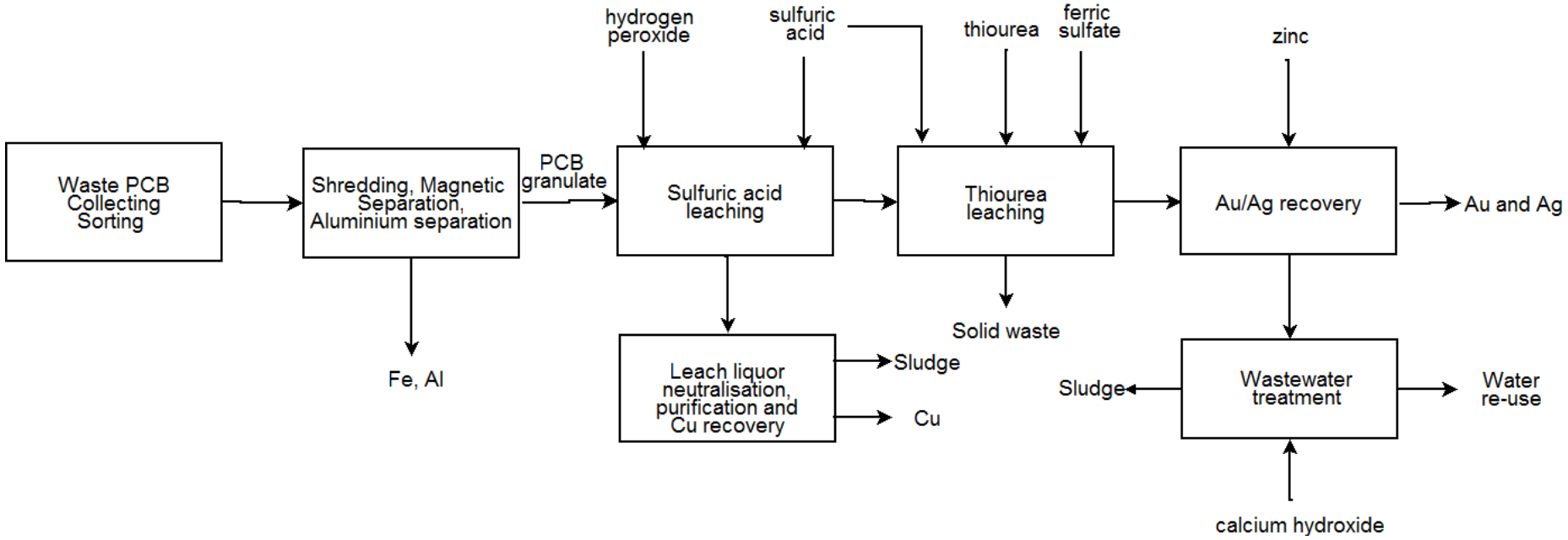
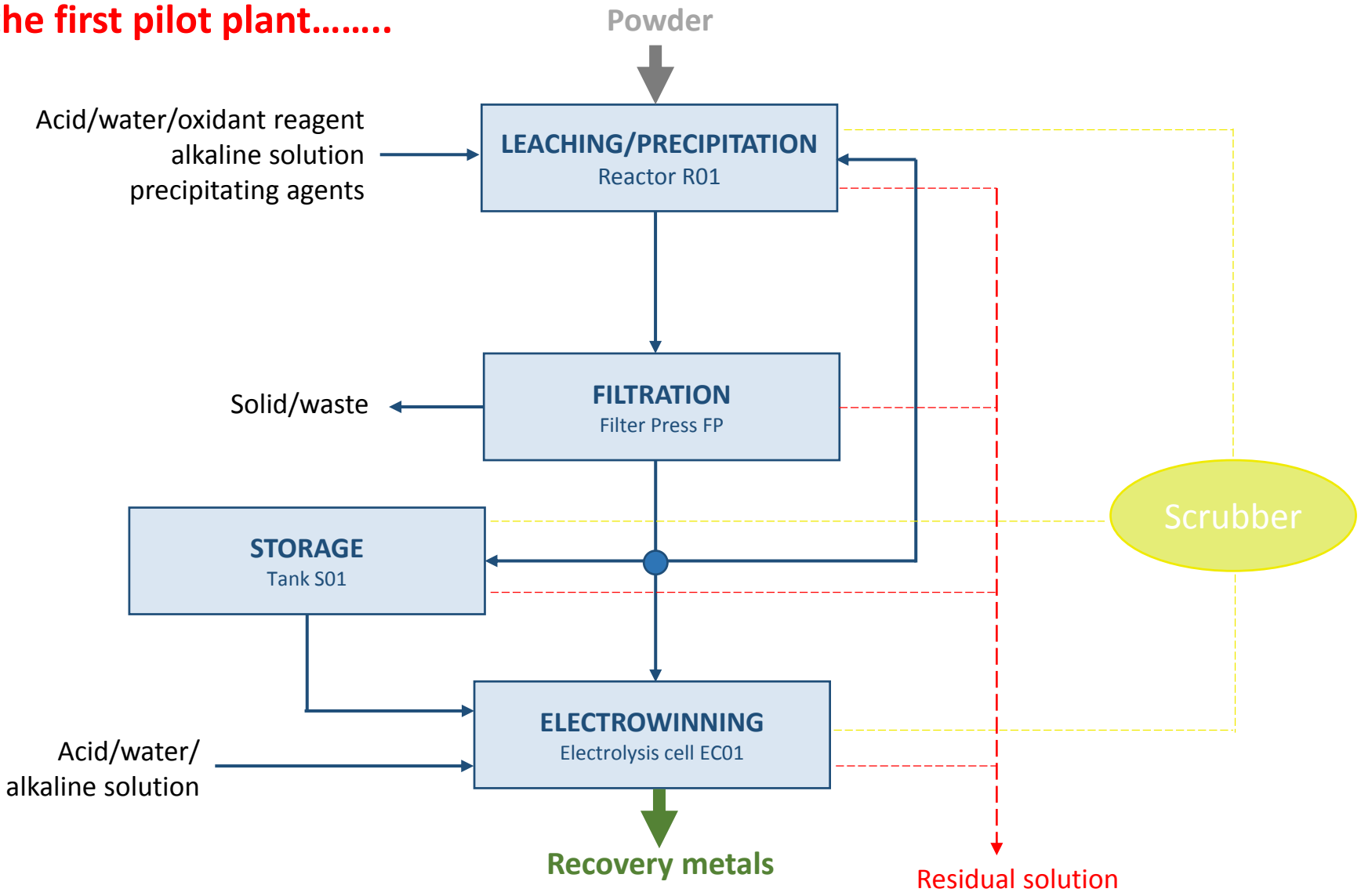
Printed circuit boards copper, gold, silver



hydroWEEE
Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

towards the first pilot plant.....



Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

Main equipments:

- Leaching Reactor (R01): 0.5 m^3 polypropylene electro-stirred reactor (max operating temperature 85°C)
- Filter press (FP)
- Electrolysis Cell (EC01): 0.5 m^3 polypropylene stirred cell. Maximum voltage 4 V, maximum current 1500 A. Graphite anodes and Aluminum cathodes

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Plant capacity: 100 kg/d

Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

The Euronews clip

3 MINUTES

http://www.euronews.com/2012/04/26/the-roaming-recycler/

hydroWEEE
Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

Patented technology:

Toro, L.; Vegliò, F.; Beolchini F.; Pagnanelli, F.; De Michelis I., Varelli E., Ferella F. (2010). **Recovery of base and precious metals from fluorescent powders and installation for implementing such method**. Patent Application in Serbia 2010/0479.

Toro, L.; Vegliò, F.; Beolchini F.; Pagnanelli, F.; Granata, G., Moscardini E. (2010). **Recupero di metalli da elettrodi di accumulatori esausti litio ione ed installazione di un impianto mobile per il loro trattamento**. Patent Application in Italy RM2010A000590.

Toro, L.; Kopacek, B., Vegliò, F.; Beolchini F.; Pagnanelli, F.; De Michelis I., Bianco B. (2010). **Recovery of base and precious metals from waste liquid crystal displays and installation for implementing such method**. Patent Application in Serbia 2010/0480.

Kamberovic Zeljko, Korac Maria, Ranitovic Milisav (2010). **Recovery of base and precious metals from waste printed circuit boards and installation for implementing such method**. Patent Application in Serbia 2010/0478.

HydroWEEE DEMO Project

Innovative Hydrometallurgical Processes to recover Metals from WEEE including lamps and batteries: Demonstration

….the scale up….

Two demonstration plants

Stationary plant

- Fixed hydrometallurgical plant (installed in the premises of the SME recycler Relight in Italy)

Mobile plant

- Hydrometallurgical plant entirely loaded on transportable containers

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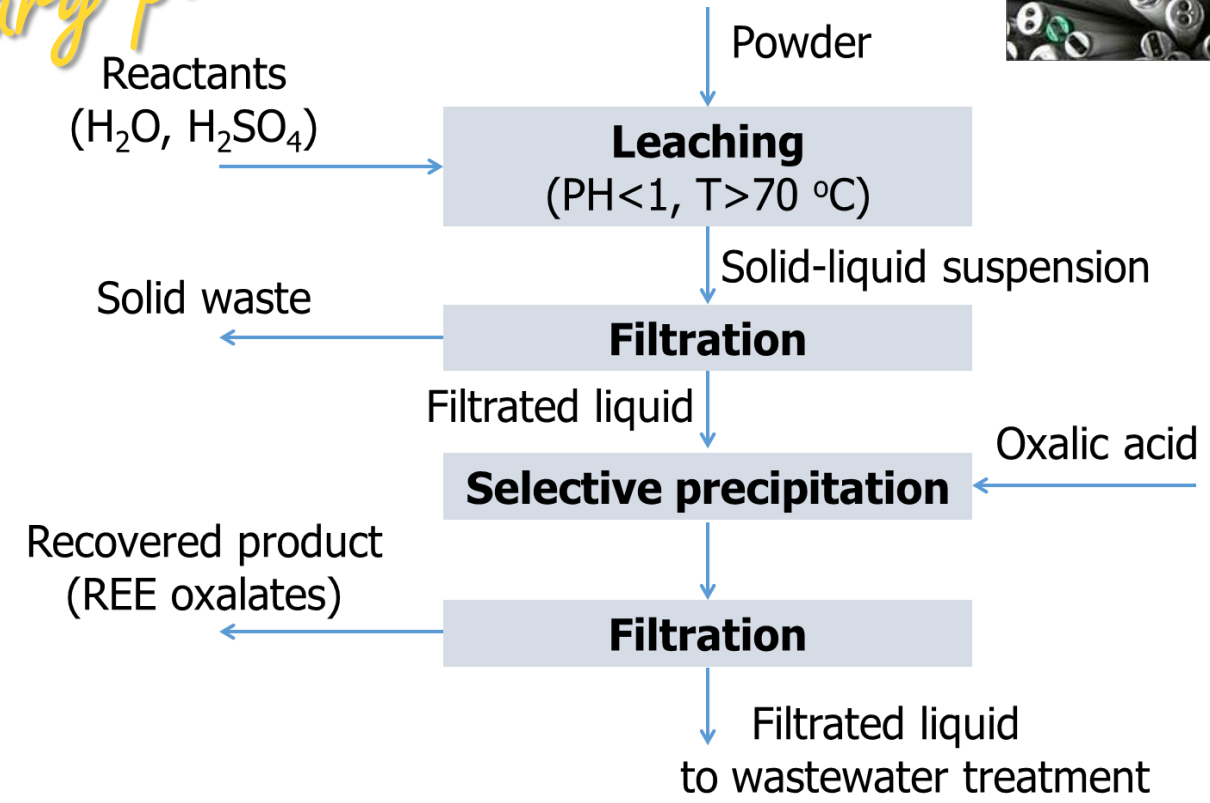
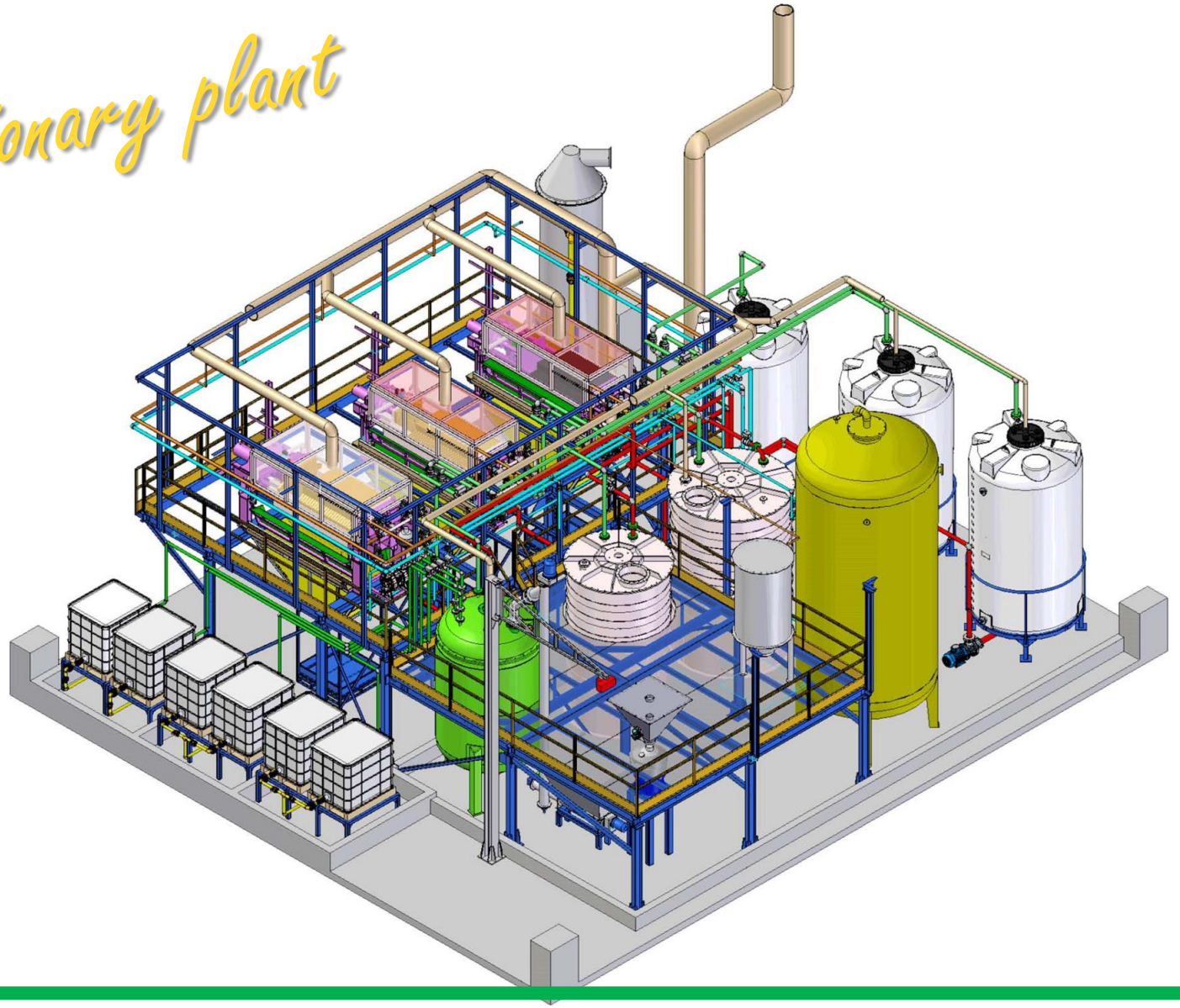
Stationary plant



Stationary plant



hydroWEEE

Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

Stationary plant

Clip

5 MINUTES

https://www.youtube.com/watch?v=3jAwAZnM3Is

hydroWEEE
Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

Stationary plant

Main achievements:

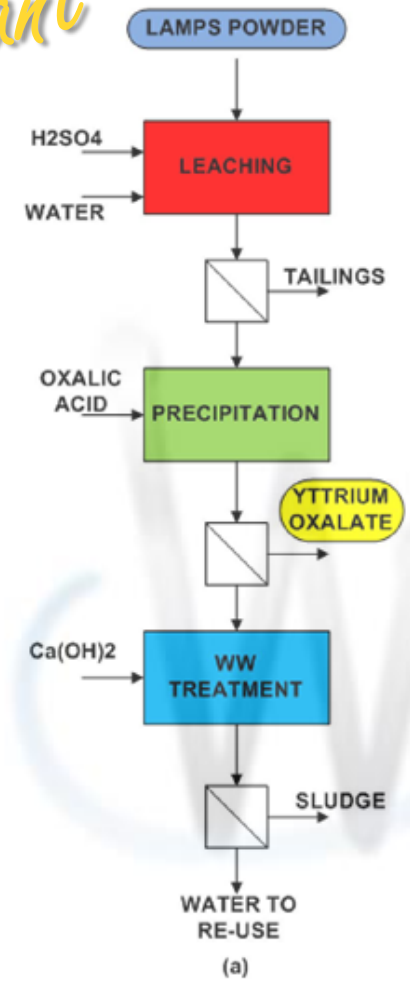
Final product composition

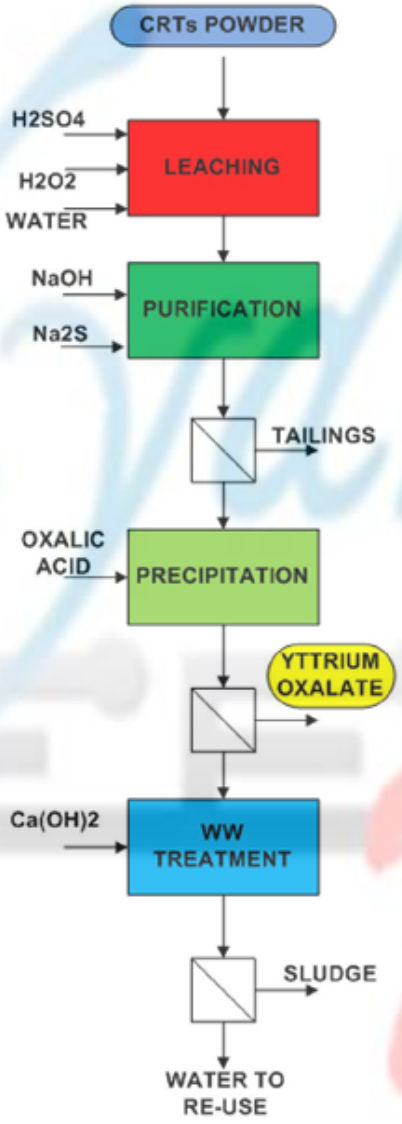
	Rare earth Oxalate (%)	Oxide (%)
Yttrium (Y)	85.1	88.78
Europium (Eu)	5.57	6.20
Terbium (Tb)	0.7	0.82
Gadolinium (Gd)	2.8	2.94
Cerium (Ce)	0.8	1.12
Lanthanum (La)	0.02	0.022
TOT	94.99	99.88

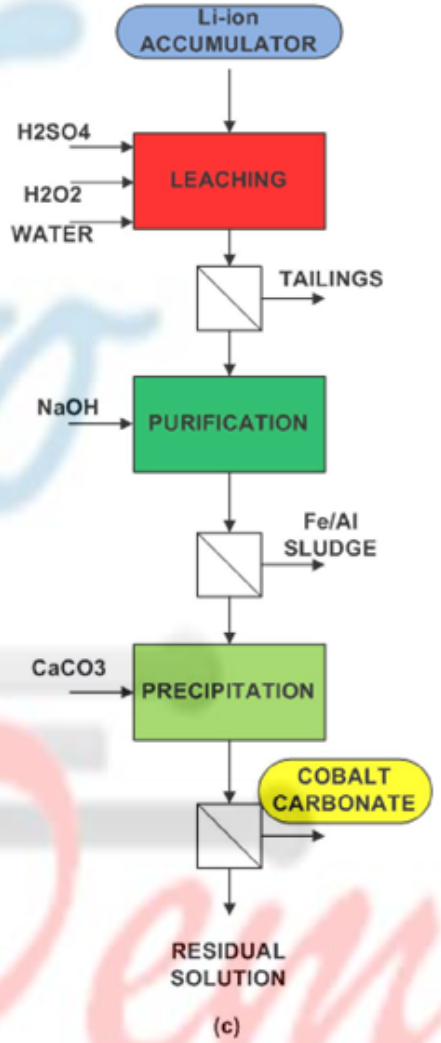
Recovery Yields (%)

Yttrium (Y)	92,5		
Europium (Eu)	95		
Gadolinium (Gd)		95	
Terbium (Tb)	12	63	after a thermal
Cerium (Ce)	10	43	pretreatment
Lanthanum (La)	< 10	29	of powders

Mobile plant

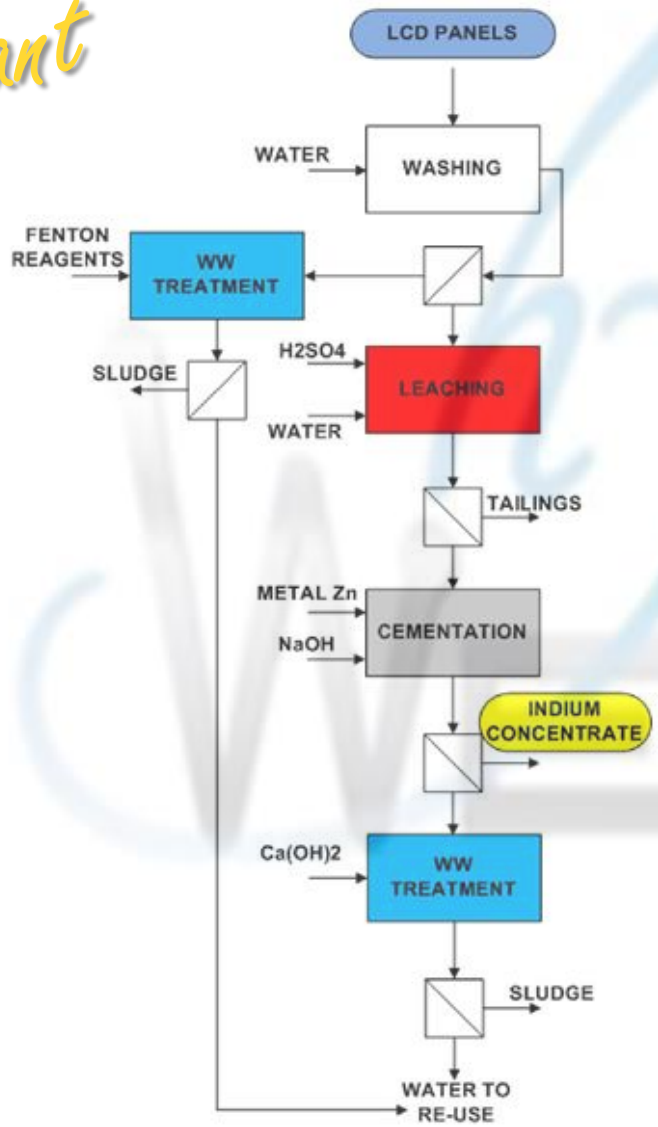






Hydro Demo

Mobile plant



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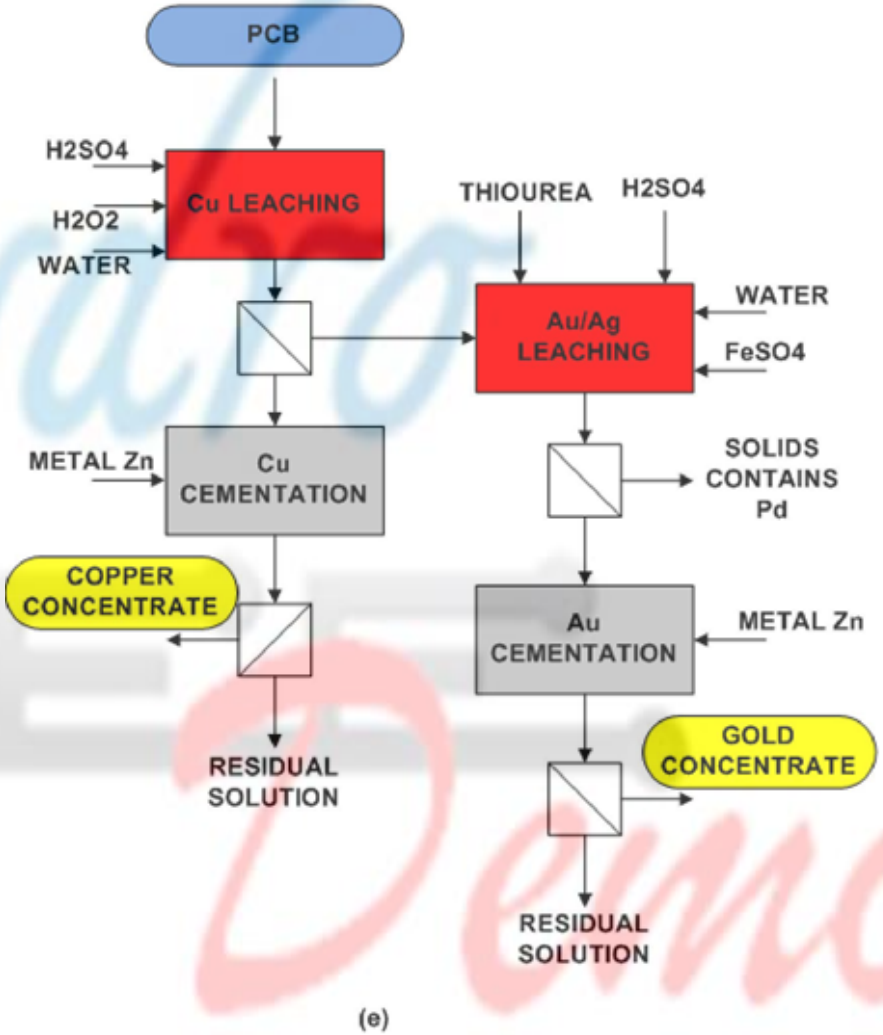
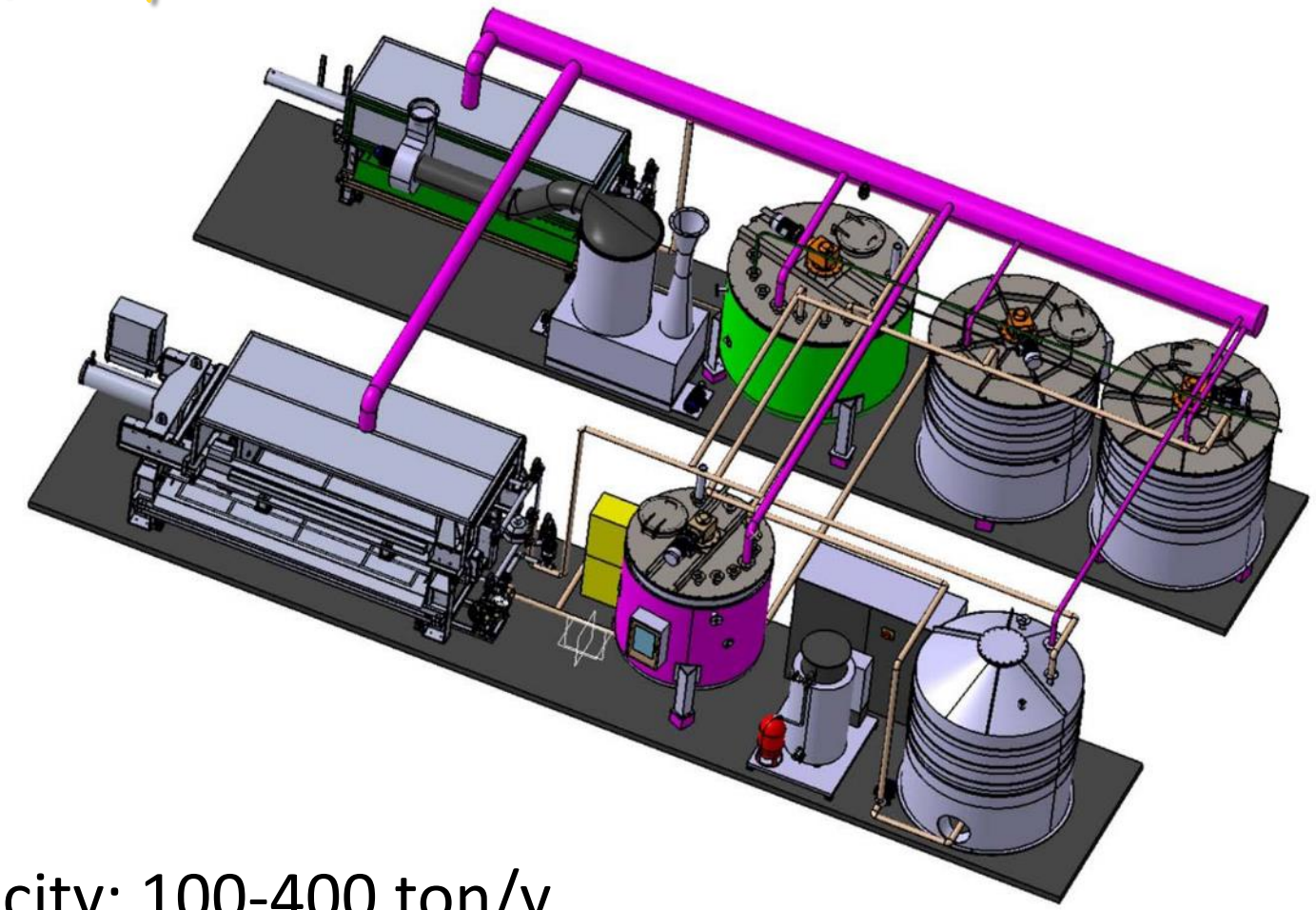


(e)

hydroWEEE

Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

Mobile plant

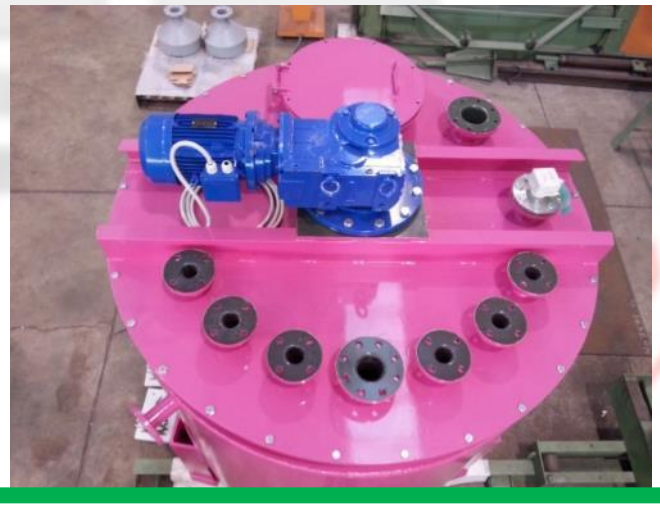


Capacity: 100-400 ton/y

Mobile plant

Main equipment description

- **Jacketed leaching reactor – R1 (n. of items 1)**
  - Volume: 4.5 m^3;
  - Material: steel internally covered with halar to ensure resistance to large temperature and acidic PH values;
  - Weight: 3500 kg;
  - Power agitation motor: 4 kW.



Mobile plant

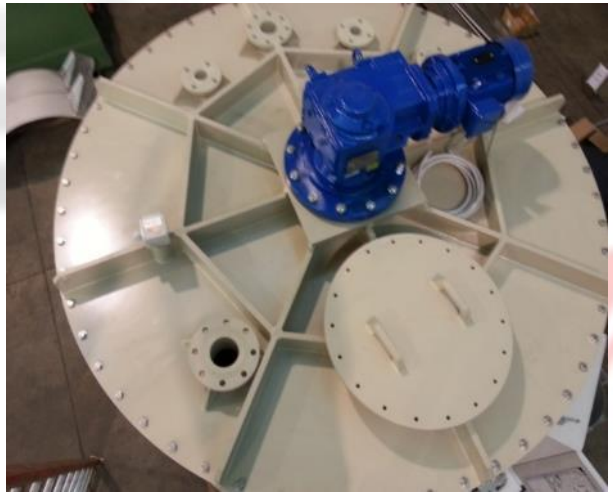
Main equipment description

- **Jacketed precipitation reactor – R2 (n. of items 1)**
  - Volume: 6 m^3;
  - Material: steel internally covered with ebanite to ensure resistance to large temperature and acidic PH values;
  - Weight: 5000 kg;
  - power agitation motor: 7 kW.

Mobile plant

Main equipment description

- **Reactor for waste water treatment – R3 (n. of items 2)**
  - Volume: 6 m^3;
  - Material: polypropylene;
  - Weight: 1000 kg;
  - Power agitation motor: 4 kW.



Mobile plant

Main equipment description

- **Filter press – FP1 (n. of items 1)**
  - Amount of sludge filtered per cycle: 3200 l with 10 % dry solid content;
  - Cycle working time: 1 hour;
  - Material: polypropylene plates;
  - Filter press weight: 6000 kg.

Mobile plant

Main equipment description

- **Filter press – FP2 (n. of items 1)**
  - Amount of sludge filtered per cycle: 3800 l with 2 % dry solid content;
  - Cycle working time: 1 hour;
  - Material: polypropylene plates;
  - Filter press weight: 1700 kg.

Mobile plant

Main equipment description

- **Tank – T1**
  - Volume: 4.5 m^3;
  - Approximate weight: 600 kg;
  - Admissible pH of the stored suspension: <1;
  - Maximum temperature: 65 °C.

Mobile plant

Main equipment description

- **Boiler**
  - Electric power and tension: 51 kW, V.400, Hz. 50;
  - Approximate weight: 300 kg;
  - Max operation pressure: 6 bar;
  - Max operation temperature: 90 °C;
  - isolation jacket in rock wool and galvanized sheet steel.

Mobile plant

Structuring containers

- Realization of structures allowing for the distribution of concentrated weights.
- Construction of a system enabling the introduction and placement of main equipment inside the container.
- Realization of additional lateral entrances allowing personnel to reach any point of the plant.
- Realization of holes for the passage of pipes, gas collectors and removal of minor equipment in case of damage.

Demo

Mobile plant

Containers

Mobile plant

Installation in the site of the partner Greentronics

Clip

5 MINUTES

https://www.youtube.com/watch?v=3jAwAZnM3Is

hydroWEEE
Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

Main achievements:

about 10 tons of residues treated in the mobile plant

fluorescent lamp powder

CRT powder

LIB black mass

ground PCB

sludge from LCD recycling

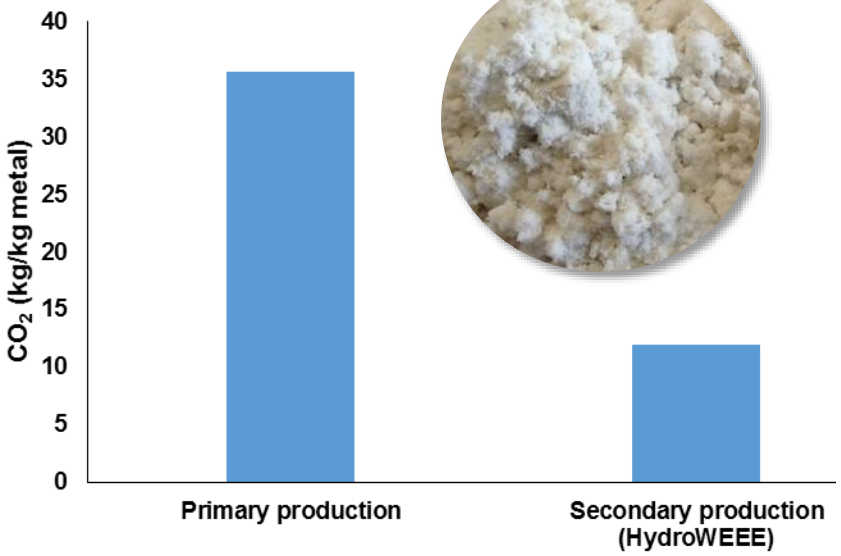
the plant was operated in Romania and in Italy

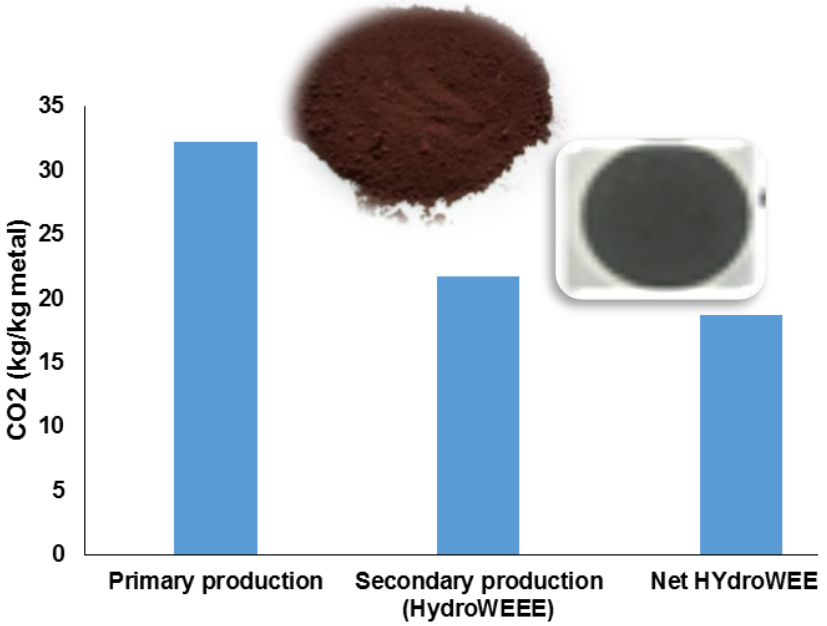
wastewater (WW) recirculation 80% re-use

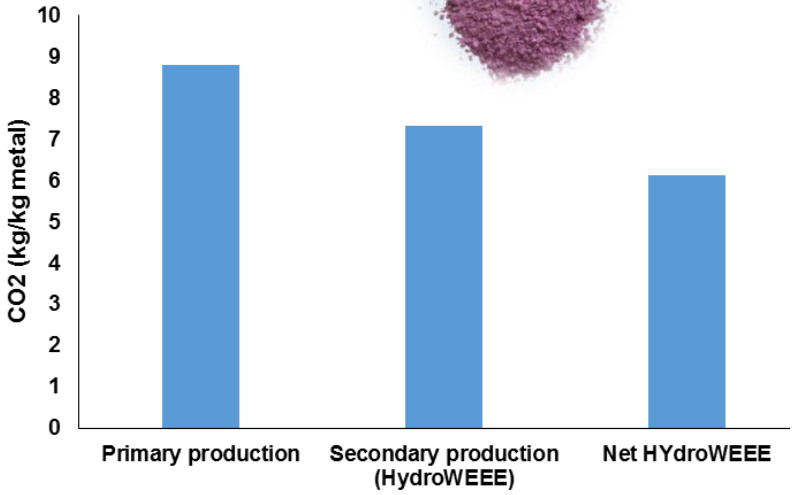
the process can be considered as replicable in a bigger scale

Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

Environmental impact assessment







Problem

Treating in profitable way even low amounts of metal-bearing wastes/residues

Small recyclers have no direct access to large processing solutions

hydroWEEE
SEVENTH FRAMEWORK PROGRAMME
Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries

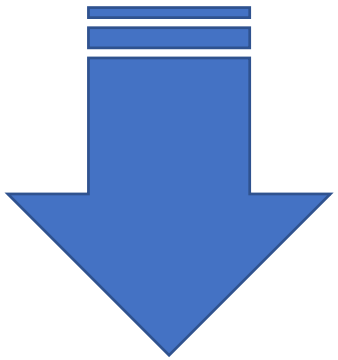
Solution

A platform technology where different applications can be carried out, to process different input streams (small amounts per input streams necessary)

Mobile plant for waste treatment in different sites, based on low impact hydrometallurgical recycling technologies

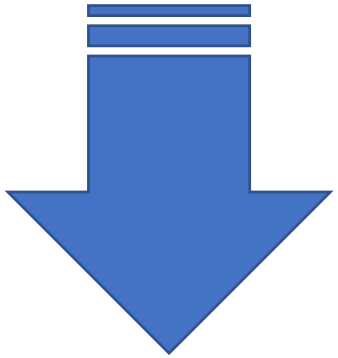
WHAT'S NEXT?

Feed preparation



MECHANICAL PRETREATMENT

Possible future improvement of the plant for the products purifications treatments in order to obtain more high added value products and to test new processes



LIQUID-LIQUID EXTRACTION UNIT (MIXER SETTLERS)

ELECTROWINNING UNIT

On going projects

PhotoLife Project LIFE13 ENV/IT/001033

Process and automated pilot plant for simultaneous and integrated recycling of different kinds of photovoltaic panels

(granted by European Commission LIFE2013 programme)

Patent: "Process for the treatment of EOL photovoltaic panels"
WO2014184816A1

EU LIFE+programme cofunded project for the demonstration of the technico-economic feasibility and environmental benefit of recycling glass and metals by treating different kinds of EOL photovoltaic panels

Eco Recycling: Coordinating Beneficiary

PhotoLife Project

PVP

Shredding

Sieving

Fine Fraction to leaching

Coarse Fraction

Solvent

Solvent Treatment

Recovered Solvent

S/L Separation

Water

Gravimetric Separation

Recovered Water

S/L Separation

Glass

Plastics

Container 1: mechanical pre-treatment unit

PhotoLife Project

PhotoLife Project

Container 2: Physical treatment unit

Control room

Operational section

Francesca Beolchini

LiBat Project LIFE16 ENV/IT/000389

Recycling of primary Lithium Battery by mechanical and hydrometallurgical operations

(granted by European Commission LIFE16 programme)

A new innovative process will be demonstrated to recycle primary lithium batteries. Demonstration activities will be performed on the prototype. Project activities will contribute to the reduction of the emissions generated if compared to pyrometallurgical processes.

Eco Recycling: Coordinating Beneficiary

Project objectives

Ongoing Projects: LiBat

- LIBAT project is aimed at the demonstration of a new **innovative process** for the recycling of primary Li batteries (Li(0)/MnO2 batteries).
- The proposed process integrates mechanical pre-treatment with a hydrometallurgical treatment route to recover plastics, ferrous and non-ferrous metals.
- Compared to alternative recycling technologies, the proposed process allows separately recovering lithium and manganese products.
- The process will be demonstrated by the construction and operation of pilot plant with processing capacity of **50 kg of batteries per day**.

Ongoing Projects

fenix

Future business models for the Efficient recovery of Natural and Industrial secondary resources in eXtended supply chains contexts

granted by European Commission programme H2020-NMBP-2017-two-stage

Coordinator: Bernd Kopacek

University of L'Aquila is a partner responsible of the adaptation of the HydroWEEE technology towards more sustainable approaches for copper and gold recovery from PCBs – biometallurgical routes will also be explored with the support of Polytechnic University of Marche

Ongoing Projects

e.THROUGH Project H2020-MSCA-RISE-2017

Thinking rough towards sustainability

(co-financed by European Commission horizon 2020 programme)

The generated scientific relevant knowledge will be transferred to shape industries, communities and individual citizens' behaviour, fostering corporate sustainability performance, important to influence economic agents' choices. e.THROUGH will generate a win-win situation for both the environment and the economy, promoting the required transition towards a sustainable society.

partners

Ongoing Projects: e.THROUGH

List of participants

#	Participant Legal Name	Country
1	NOVA ID FCT - ASSOCIACAO PARA A INOVACAO E DESENVOLVIMENTO DA FCT	Portugal
2	DANMARKS TEKNISKE UNIVERSITET	Denmark
3	UNIVERSIDAD DE MALAGA	Spain
4	ECO RECYCLING S.R.L.	Italy
5	AMPHOS 21 CONSULTING SL	Spain
6	E-MINES	France
7	LOMARTOV SL	Spain
8	NORTHEASTERN UNIVERSITY	United States
9	LEHIGH UNIVERSITY CORPORATION	United States

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