Deliverable D 2.2
Mobile product-like industrial demonstration plant

<table>
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<tr>
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<tr>
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<td>March 2014</td>
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This deliverable contains the description of the full-scale, industrial mobile plant that has been realized within the HydroWEEE-Demo project. The plant can treat several types of residues of the WEEE recycling processes, such as fluorescent powders from fluorescent lamps and cathode ray tubes, ground printed circuit boards, ground electrodic material of Li-ion batteries and ground LCD panels. The mobile plant has been realized in two containers and its capacity has been optimized in order to be the largest possible.

The plant has the following features, that have been considered as very relevant for the plant to be run in the sites of typical European SME WEEE recyclers:

- strengthened structure and special robust, flexible fixtures for piping and equipment, in order to reduce the risk of eventual breaks during transport;
- normal electricity/water requirements;
- wastewater treatment included, aiming at closing the water loop – limit the amount of fresh and waste water as well waste water in a quality that can be dumped in the normal sewage system;
- special set-up of mobile plant for outside operation (with rain, snow, wind, …);
- thermal insulation for operation in winter time/cooling for summer time;
- precautionary measures to protect “untrained” personnel and the environment from any damage;
- allowing not only the 5 current input materials, but flexible processes with different inputs in future;
- only 1 person necessary to operate the plant including feeding, storing output material;
- “self-healing”/ robust processes and programming;
- “plug and play” – self testing, self-calibration, … at set-up/ramp-down;
- automatic reporting (operation/failure/mass balance/…) per day, week, month, … accessible from office location.

In the following sections the main development for the design and construction of the plant are presented.
1. Plant Layout

The plant was realized in two mobile units having the following internal dimensions: 13.55 m of length, 2.90 of height and 2.47 m of weight. For the development of the layout many considerations were made and the equipments were dimensioned to have a maximum potential with the available spaces. To maximize space, the best possible position for the equipment is that reported in Figure 1.

![Figure 1: Layout of the equipment in the mobile plant](image)

The unit 1 contains the main equipments to leach the initial material with acid solution and to filter the suspension. The solution is sent to the second container in which the reactor and filter press to recover rare earths, base metals and precious metals are positioned together with the equipment dedicated to wastewater treatment.

Figure 2 shows the 3D image of the plant in which a complete view of the entire system can be seen; it was the base that was used to realize the real plant.
The main equipment is the following:
- Leaching reactor (pink reactor), R1
- Filter press for leaching suspension, FP1
- Recovery reactor (green reactor), R2
- Filter press to recover final products, FP2
- Wastewater treatment section with two reactors, R3-1 and R3-2
- Scrubber for air treatment, S1
- Boiler to heat the leaching reactor, B1.

The plant is also equipped with a compressor for pneumatic control devices, electrical and PLC panels.
- The materials for the plant and for piping were chosen to resist both acid and basic conditions of the hydrometallurgical processes. Furthermore, it has been designed limiting the times that the personnel should enter into containers.

The following Figures show the 3D images and the real photos of some equipment installed inside the containers.
Figure 3: Leaching reactor R1 – Mobile plant, HydroWEEE demo

Figure 4: Filter press FP1 – Mobile plant, HydroWEEE demo

Figure 5: Filter press FP2 – Mobile plant, HydroWEEE demo
The reactors are equipped with mixing system fundamental for the kinetics of the reactions and to keep the solids in homogeneous suspension. Figure 7 shows the mixing system of reactor R1, as example.

2. Mobile plant Construction

As for every chemical plant’s construction, several practical difficulties were solved. In the present case, for example, the major aspects were how to place the equipments inside the mobile units given limited size and in which manner a person could enter in the containers to reach the equipment that requires any maintenance. For these reasons several opening on the walls of the containers were planned: the phases of the unit modifications are reported in Figure 8.
Other practical questions were about the criteria to put piping inside the units, to connect the equipment with reagent tanks outside the plant and to connect the two containers. Figure 9 shows the opening for the tubes that connect container 1 and 2.

![Opening for piping – Mobile plant, HydroWEEE demo](image)
After this phase, the real construction of the plant was considered. Several precautions were taken to place the equipments as shown in the Figure 3. The following photos (Figure 10) report the main phases to install the reactors, filterpress, boiler, …
3. Hydrometallurgical Process and Capacities

The mobile units is design to treat several types of waste, especially fluorescent materials from lamps and CRTs, PCB’s powders, Li-ion batteries and LCD panels. Considering the useful volume of the leaching reactor (R1) and 10% or 15% pulp density to carry out the dissolution of the materials, the capacity for batch is around 280 kg/cycle and 420 kg/cycle, respectively. This means that for year around 62 T or 92 T can be treated (220 day/years). This capacity could increase and more batches for day could be performed in according to Gantt Chart and considering 16 working hours for day (two shifts of 8 h), the total maximum amounts are:
- 300 T/y for lamps and CRTs processes
- 200T/y for PCBs process
- 200T/y for LIB process
- 1000--- T/y for LCD process
4. Conclusions – Mobile plantrunning

The mobile plants realized within HydroWEEE demo project is consists of two mobile units, it is compact, can be moved with common transports, is flexible and could be used to treat several types of waste (i.e. WEEE and batteries).

The final products that could be recovered from waste studied until now in the HydroWEEE’s project are reported in the Table 1.

<table>
<thead>
<tr>
<th>Initial material</th>
<th>Products</th>
<th>Average composition</th>
<th>KG / KG OF RAEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamps</td>
<td>Rare earthsosalates</td>
<td>Y (34.32%); Eu (1.96%); Gd (0.99 %)</td>
<td>0.32</td>
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<tr>
<td>Lamps</td>
<td>Cake afterleaching</td>
<td>Y(0.87%); Tb (0.18%); Eu (0.10); Gd (0.17%); La (0.19%); Ce (0.35%)</td>
<td>1.03</td>
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<tr>
<td>CRT</td>
<td>Rare earthsosalates</td>
<td>Y (33.65%); Eu (2.07%); Zn (32.3%); Gd (0.007 %)</td>
<td>0.27</td>
</tr>
<tr>
<td>CRT</td>
<td>Cake after leaching</td>
<td>Y (3.3%); Zn (32.3%)</td>
<td>0.67</td>
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<tr>
<td>PCB</td>
<td>Copper</td>
<td>Cu (88.6%); Zn (6.7%); Sn (0.5 %); Fe (0.2 %)</td>
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<tr>
<td>PCB</td>
<td>Gold/Silver</td>
<td>Au (8%); Ag (27%); Zn (65%)</td>
<td>0.0014</td>
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<tr>
<td>PCB</td>
<td>ZnSO₄ solution</td>
<td>Zn (4.35%); Cu (0.03%); Sn (0.009%); 7.58</td>
<td></td>
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<tr>
<td>LCD Panels</td>
<td>Indium</td>
<td>In (10%), Fe (1%), Al (10%), Zn (80%)</td>
<td>0.002</td>
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<tr>
<td>Lithium Batteries</td>
<td>Cobaltcarbonate</td>
<td>Co: 20%; Li 1.2%; Ni 4.5%; Mn 3.3%; Al 0.8%</td>
<td>0.3</td>
</tr>
<tr>
<td>Lithium Batteries</td>
<td>Graphite (cake after leaching)</td>
<td>Co: 0.5%; Li: 0.1%; Fe: 0.08%; Cu 0.1%; Ni 0.01%; Mn 0.01%; Al: 0.01%</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Table 1: Products (lab data) that could be obtained by hydrometallurgical processes performed in the mobile plant

The plant has been realized in EcoRecycling premises and it has been moved to Alessandria (Figure 12 and Figure 13) in Greentronicss site; first tests were performing.
Figure 12: Operations of transport of the mobile plant to Greentronic’s site

Figure 13: Mobile plant in Greentronic’s site