

## Description of the potential impact and the main dissemination activities and the exploitation of results

### 1. Potential Impacts

#### Lead Market Initiative for Europe 4: Recycling: proper and effective waste management

Recycling reduces waste going to landfill, consumption of natural resources and improves energy efficiency. It therefore plays an essential role in the move towards sustainable consumption and production as well as resource efficiency. **The recycling sector has a turnover of 24 billion € and employs about 500.000 persons globally. The EU has around 30% of the world share of eco-industries and 50% of the waste and recycling industries.**

Despite significant market potential, barriers to market development remain. There is also significant potential to improve efficiency and capacity, by encouraging innovation and introducing more effective processes and technologies. This will save costs, energy and natural resources and help Europe to be less dependent on raw materials prices.

**Emerging green technologies** such as photovoltaics (PV) and solid-state lighting (SSL) **do heavily depend on the use of raw materials like gallium, indium and rare-earth elements (including yttrium).**

Figure 3.1 shows the projected growth for the two first-mentioned metals, indicating that global supply will increasingly lag behind on demand if the current circumstances pertain. The growing demand is driven by PV, SSL (notably light-emitting diodes / LEDs) and electronics (integrated circuits) for gallium and by PV and electronics (liquid crystal displays / LCDs) for indium. Meanwhile the primary production and trade of these materials is highly controlled by a few countries and particularly by China. For rare-earth elements a similar tight situation exists with global annual demand being projected to rise to 170,000–190,000 tons by 2014 and associated Chinese production of 160,000–170,000 tons being subject to export cuts. A further complication for both gallium and indium is that they are mined as by-products of other materials.

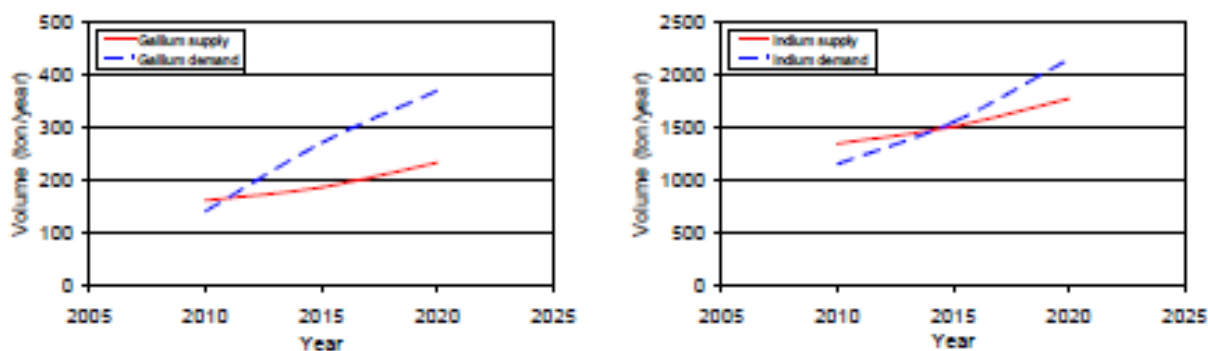


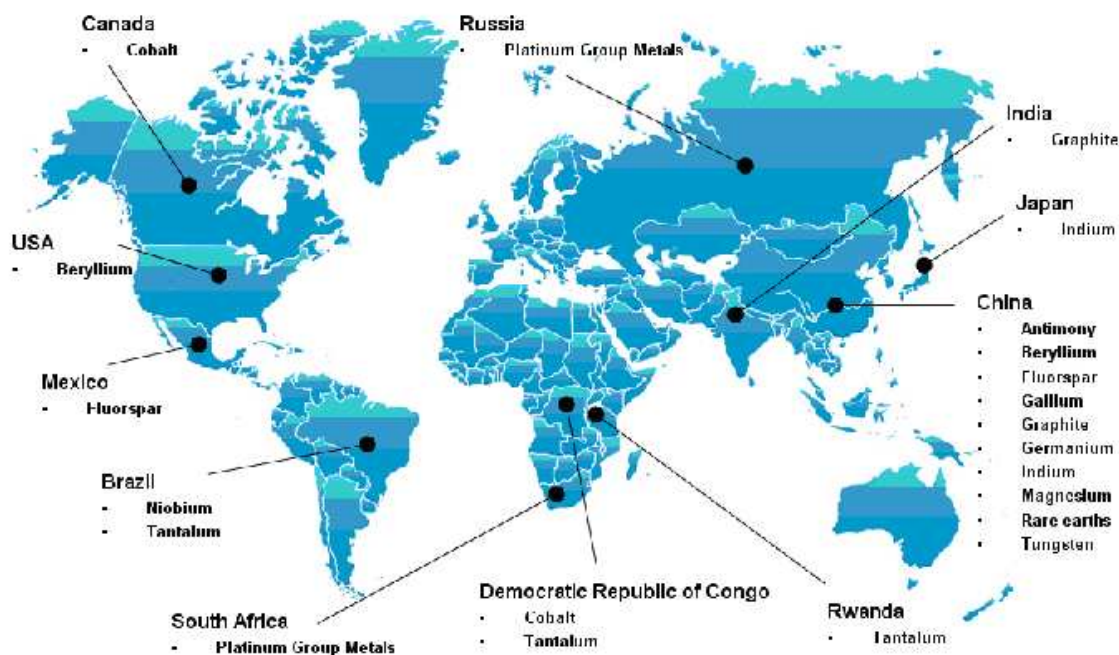
Figure 3.1 World-wide supply and demand forecasts for gallium (left) and indium (right)

The previous obviously poses a problem as it renders Europe particularly susceptible for the provision of these increasingly scarce materials that are crucial for meeting policies on energy renewability and energy saving (amongst others implemented in the EU ban on the incandescent bulb by 2012 and the phasing out of the halogen bulb by 2016) as well as for the further development of these sectors with apparent economical and employment implications. This is also expressed by a recent EC report of the **Raw Materials Initiative** and its definition of **14 economically important raw materials** which are subject to a higher risk of supply interruption:

Antimony	<b>Indium</b>
Beryllium	<b>Magnesium</b>
<b>Cobalt</b>	Niobium
Fluorspar	PGMs (Platinum Group Metals) - <b>platinum, palladium</b> , iridium, rhodium, ruthenium and osmium
<b>Gallium</b>	Rare earths - <b>yttrium</b> , scandium, <b>lanthanum</b> and the so-called lanthanides ( <b>cerium</b> , praseodymium, neodymium, promethium, samarium, <b>europium</b> , gadolinium, <b>terbium</b> , dysprosium, holmium, reberium, thulium, ytterbium and lutetium)
Germanium	Tantalum
Graphite	Tungsten

There are a number of reasons for this heightened supply risk. One of which is the high concentration of the production of a raw material in a given non-EU country. Other reasons are the low political-economic stability of the main supplier(s), as well as the low substitutability and low recycling rates of the raw material itself. The graphic below [*Critical raw materials for the EU*; report of the ad-hoc working group on defining critical raw materials; EU DG Enterprise and Industry, June 2010] presents the production concentration of the critical raw materials by source country.

### Production concentration of critical raw mineral materials



HydroWEEE can extract already now 3 of those critical materials from WEEE and will expand it during follow-up projects to even more (e.g. Cerium, Platinum, Palladium, Europium, Lanthanum, Terbium, ... will be in the focus).

By that it is also perfectly in line with the **Europe 2020 Strategy** and its **flagship initiative on a “Resource Efficient Europe”** (including its recently published roadmap), **Eco-Innovation Action Plan, EU Horizon 2020, ...**

As **WEEE is a European challenge (it will increase by 11% between 2008 and 2014)**, the mobile plant will tour through several European countries and the consortium is covering 3 EU member states and 1 associated country, a European approach is necessary and justified.

As mentioned before the recycling business is traditionally dominated by small and medium sized enterprises. These can be also seen in the latest data from Eurostat for the recycling sector in EU27:

Number of companies	14.400
% SME	80%
Turnover (in Mio €)	30.000
Value creation (in Mio €)	6.300
Employees	130.000

**Summarised the HydroWEEE technology has potential to boost European competitiveness by applying novel processes for improved resource efficiency by extracting rare and precious metals from WEEE and other sectors. Furthermore it will reduce Europe's dependence on foreign raw material sources (e.g. recent export ban of rare earth metals from China) and by that make the European industry more independent and vulnerable.**

HydroWEEE will contribute to several **EU policies and societal objectives** concerning:

**Employment:** **Creation of new 150 interesting and high-skilled jobs.** It will do so by facilitating the creation of new and strengthening of existing enterprises; by accelerating the transfer and the dissemination of the RTD results; by upgrading employers' skills through customised training programmes, etc.

**Environment:** **Better protection of the environment.** Eco-efficient recycling will reduce dramatically their overall environmental impact (minimising waste, resource consumption and energy usage).

**Climate change:** By developing a mobile plant that can be operated on several places by different SMEs, a phenomenon of today will be opposed. Today a lot of WEEE is transported from its collection place over a very long distance to its treatment location. For example STENA collects WEEE in Denmark and dismantles everything in Poland and processes the CRT glass in Germany. Only because of this more than 7000 trucks run through half of Europe every year. Most of the other multinational companies are doing the same. These transports will be reduced because of the mobile HydroWEEE plant. This will **save a lot of resources for petrol and limit the CO<sub>2</sub> emissions caused by transport.**

**Raw Materials:** **Recycling rare and precious metals from End-of-Life products will reduce the dependence of European industry on foreign raw material sources and make it more competitive.** By recycling the materials in Europe these materials can substitute imports from politically instable countries.

**Waste Export:** Especially in a lot of EU countries with a coastline (e.g. UK, France, Italy, Spain, ...) a lot of WEEE is currently **loaded in containers and then cheaply transported to Third World countries like China, India, Malaysia.** There nobody can control what happens to this products and if they are recycled in an appropriate manner. NGOs like Greenpeace or the Basel Action network estimate that more that the majority of WEEE from USA and EU are still exported in such a way. HydroWEEE will close the loop within smaller regions and generate more profit for the SMEs in order to oppose this problem.

**Health:** **Improved health of the EU's citizens.** Recycling most of the materials within a country and reducing transports will all improve the life-support systems of mankind.

Based on most recent data from the Environmental data centre on waste, the WEEE Forum and the European Portable Battery Association the following potential markets will be tackled:

2008 figures	CRT	LCD	Lamps	Printed boards	circuit	Lithium batteries
Volume collected (tons)	482.000	85.000	35.600	50.000		2.200
Potential inflow material to HydroWEEE process (tons)	960	5.530	1.160	50.000		1.100
Potential number of plants	10	28	6	100		6

Especially the 2 markets on LCDs and Li-batteries will increase dramatically:

- Currently most of the **CRT-based TV-sets and computer monitors are replaced by LCDs** which will come back in larger quantities in 5-10 years.
- The collection of Li-batteries is already today growing by 300% per year. A real **boost the Li-batteries will face with electro-mobility**. For example Germany alone wants to have 1 million electric cars on the road by 2020. Each of them will have a Li-battery with between 400 and 700 kg which means 400-700.000 tons only for Germany or **about 3-5 million tons of Li-batteries for Europe**.

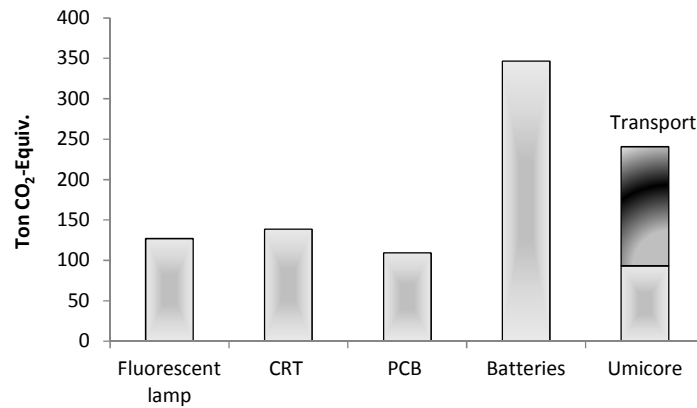
The HydroWEEE consortium has already agreed to market all products and services via a newly founded **spin-off company**. **All SME partners will benefit from the activities both directly as end-users of the plants (Relight, SET, Greentronics) by increased competitiveness on their local markets or technology suppliers (EcoRecycling) by selling plants or services as well as indirectly as shareholders of the new spin-off company or through royalties paid by the commercializing partner.**

HydroWEEE will exploit all process developments by building mobile (on special request also stationary for larger quantities in one location) plants and selling, leasing, renting, franchising them to the more than 3.000 SME and other recyclers active in the field of WEEE in Europe. Not only the target group of HydroWEEE are mainly SMEs, but also **all project partners are SMEs and consequently more than 80% of the total EC funding is going to those SMEs.**

With the mobile plant we will have the best means for demonstrating the credibility and (technological, financial, environmental and social) robustness of our business case to interested parties (we can come with the mobile plant to their site and process their material under their "eyes"/direct control) and by that convince them to buy our plant or become customers of our services.

**Therefore we see a market for 50-100 stationary as well as mobile plants until 2020. This represents roughly a turnover of 35-70 million € and the creation of about 150-200 skilled and meaningful jobs.**

Based on a preliminary LCA (a more detailed LCA is part of this proposal) especially the mobile solution shows considerable benefits compared to today's solution:



**Figure – CO<sub>2</sub> emissions of different treatments aimed at the recovery of valuable metals from 100 t WEEE carried out by the mobile plant of the HydroWEEE plant (first 4 treatments) and by Umicore [Meskers C.E.M., Hagelüken C., Van Damme G., Green recycling of EEE: Special and precious metal recovery from EEE. The Minerals, Metals & Materials Society, 2009.]. In the latter case, CO<sub>2</sub> emissions of transport (2000 km) were considered.**

It shows that especially **eliminating the transport of fractions across Europe to the treatment plant is giving excellent advantages for the mobile plant.** The HydroWEEE batteries process cannot be directly compared to the normal Umicore smelting process because also for Li-batteries Umicore has just recently implemented a pyro-metallurgical process where no LCA data have been published so far.

The **general impact** of the HydroWEEE project can be highlighted by the following aspects:

- First of all a **new company will be founded** (already in progress) that will exploit all process developments by building mobile and stationary plants and selling, leasing, renting, franchising them to the more than 3.000 SME recyclers active in the field of WEEE in Europe. Based on this figure and the assumption that one mobile plant can serve on average 5-10 SME recyclers, **the potential of 300-600 processing plants** have been calculated.
- There is the intention to use the mobile pilot plant as a **shared research facility** for the involved SMEs at EcoRecycling. It is well known that normally SME have not research facilities that are able to develop and resolve complicated research needs. Thus it will open up new opportunities to create commercial links between the different SMEs involved in this project reinforcing the capacity building of these companies;
- There will be **major environmental benefits** if the specific goals of each SME will be reached in terms of reduction of disposed wastes, valorisation of some materials optimising the consolidated processes and reaching the standards imposed by some EU directives;
- The **economic benefits** will create the optimal condition to improve the gross profit of the companies and increase employment especially for high level-profile professionals. For example the WEEE market alone is estimated to reach more than 17 million tons in Europe this year.

## 1.1 Impact for the SME participants

The specific impact of the involved SMEs can be listed in the following:

- **Relight** is a company that runs a plant treating spent lamps and CRTs (WEEE). Actually they produce some powders rich in Yt and Zn that are sent to landfill which increases their treatment cost. With the HydroWEEE plant Relight can increase its competitiveness by generating income from Yt and Zn instead of paying money for the landfill. So also **Relight will increase its volumes by 50%**. In addition Relight will expand into the treatment of LCDs and secure its leading market position in Italy.
- **EcoRecycling** will have the possibility to improve its know how for hydrometallurgical treatments of electr(on)ic waste and concentrate on batteries. **EcoRecycling will start to build industrial plants and become a major player for hydrometallurgical plant engineering and realization in Europe.**
- **Greentronics** will increase its knowledge on treatment of lamps, printed circuit boards, CRTs and LCDs and batteries. By the HydroWEEE plant Greentronics intends to **at least double its treated volumes in Romania from 1.500 -2.000 tons to 3.000 – 5.000 tons per year.**
- **SET** will use the HydroWEEE plant to decrease its dependency on treatment capacities abroad. With the existing MeWA line the WEEE material can be only reduced in size and sorted into different fractions that have to be treated further. The nearest treatment plants for most of this output fractions are more than 1000 kilometers away in Austria. This increases the costs for SET a lot (transportation, margin of Austrian companies, ...) and makes them dependant. By the mobile HydroWEEE plant most of the valuable fractions will be treated on site. **This increases SET's profitability and lead to 10-times bigger volumes as at the moment they are still a start-up.**
- The **newly founded spin-off company** will build and market the developed mobile plant as well as develop also stationary plants for bigger volumes. Based on the assumption that about 10% of the theoretical market volume of 600 plants can be realized within 10 years (50-100 plants until 2025) and an average sales price for the machinery of 700.000 € each, the turnover will be 35-70 million € until 2025. Additional turnover will come from the trading of the recovered material as it will make sense to pool them in order to achieve best prices on the global markets. So finally the preliminary projections add up to an **annual turnover of 5-7 million € and 30-40 employees for the newly founded company.** All 5 SMEs will benefit from this profit as they will be the sole shareholders.

## 2. Major dissemination activities

### **Going Green - CARE INOVATION 2010**

**Date:** November 8-11, 2010

**Location:** Schoenbrunn Palace, Vienna, Austria ([www.care-electronics.net/CI2010](http://www.care-electronics.net/CI2010))

**Participants:** 416

### **HydroWEEE Dissemination 2011**

**Date:** May 18, 2011

**Location:** Hotel Litta Palace, Milano, Italy

**Participants:** 40

### **Green Electronics 2011**

**Date:** November 8 – 10, 2011

**Location:** Hotel Novotel, Bucharest, Romania

**Participants:** 111

## 3. Exploitation of results

The partners within the HydroWEEE consortium have agreed to exploit the results by setting up a jointly owned spin-off company. The newly founded spin-off company will build and market the developed mobile plant as well as develop also stationary plants for bigger volumes.

This newly founded company will:

- be the holder of all patents
- own the mobile plant
- commercialize the mobile plants by licensing, renting, selling or as a franchise system
- trade with the output materials from the HydroWEEE processes because of the economy of scale

At the moment the following equal distribution of shares is foreseen (based of the individual contributions of the companies):

- EcoRecycling 35,00 %
- Greentronics 27,55 %
- SETrade 19,75 %
- Relight 17,70 %

The founding contract has been negotiated and is available in the deliverable 6.2

The newly founded company will be also the owner of all Patents:

- Process of lamps and CRT glass recycling
- Process of LCD recycling
- Process of PCB recycling

Currently the following partners have applied for an EU Patent:

- EcoRecycling
- Greentronics
- Relight

Patent number	Patent name	Year of application	Applicants	Location
2010/0479	Recovery of base and precious metals from fluorescent powders and installation for implementing such method	2010	Toro, L.; Vegliò, F.; Beolchini F.; Pagnanelli, F.; De Michellis I., Varelli E., Ferella F.	Serbia
RM2010A000590	Recupero di metalli da elettrodi di accumulatori esausti litio ione ed installazione di un impianto mobile per il loro trattamento	2010	Toro, L.; Vegliò, F.; Beolchini F.; Pagnanelli, F.; Granata, G., Moscardini E.	Italy
2010/0480	Recovery of base and precious metals from waste liquid crystal displays and installation for implementing such method	2010	Toro, L.; Kopacek, B., Vegliò, F.; Beolchini F.; Pagnanelli, F.; De Michellis I., Bianco B	Serbia
2010/0478.	Recovery of base and precious metals from waste printed circuit boards and installation for implementing such method	2010	Kamberovic Zeljko, Korac Maria, Ranitovic Milisav	Serbia

Fig. 1: Patent applications in 2010

APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.			
Type of IP Rights: Patents, Trademarks, Registered designs, Utility models, etc.	Application reference(s)	Subject or title of application	Applicant (s)
Patent (European patent office)	The patent is in progress	Process for printed circuit boards recycling	EcoRecycling, Relight, Greentronics
Patent (European patent office)	The patent is in progress	Process for LCDs recycling	EcoRecycling, Relight, Greentronics
Patent (European patent office)	The patent is in progress	Process for lamps and CRT glasses recycling	EcoRecycling, Relight, Greentronics

Fig. 2: Applications for Patents, Trademarks, Registered Designs, etc.

### List of all exploitable foregrounds (short term view):

EXPLOITABLE FOREGROUND					
Exploitable Foreground (description)	Exploitable product(s) or measure(s)	Sector(s) of application	Timetable, estimated commercial use	Patents or other IPR exploitation (licenses)	Owner & Other Beneficiary(s) involved
Hydrometallurgical recycling of Lithium Batteries <sup>1</sup>	Lithium recovery Cobalt recovery Recycling plant	Recycling	Lithium recovery (2013) Cobalt recovery (2013) Recycling plant (2013)	There are no plans for an cross-Europe patent	Spin off company
Hydrometallurgical recycling of Fluorescent powders <sup>2</sup>	Zinc recovery Yttrium recovery Recycling plant	Recycling	Zinc recovery (2013) Yttrium recovery (2013) Recycling plant (2013)	EU patent is in progress	Spin off company
Hydrometallurgical recycling of panels from LCD wastes <sup>3</sup>	Indium recovery Recycling plant	Recycling	Indium recovery (2014) Recycling plant (2014)	EU patent is in progress	Spin off company
Hydrometallurgical recycling of Printed circuit boards and other electronic scraps <sup>4</sup>	Copper recovery FeNi cement recovery Dore cement powder recovery (Au+Ag) Zinc recovery Recycling plant	Recycling	Copper recovery (2013) FeNi cement recovery (2013) Dore cement powder recovery (Au+Ag) (2013) Zinc recovery (2013) Recycling plant (2013)	EU patent is in progress	Spin off company

The final decision which countries will be finally chosen for the patenting is still in progress.



## List of all exploitable foregrounds (middle and long term view):

Exploitable Foreground (description)	Exploitable product(s) or measure(s)	Sector(s) of application	Timetable, estimated commercial use	Patents or other IPR exploitation (licenses)	Owner & Other Beneficiary(s) involved
Hydrometallurgical recycling of photovoltaic cells <sup>5</sup>	Recovery of Indium, Germanium, Gallium, Selenium, Tellurium, Antimony and Copper	Recycling	The research and development of recovery of materials is planned for 2017	A patent is planned for the process after the research and development work	Spin off company will be owner
Hydrometallurgical recycling of magnets <sup>5</sup>	Recovery of Neodymium, Dysprosium, Samarium and Lanthanum	Recycling	The research and development of recovery of materials is planned for 2015	A patent is planned for the process after the research and development work	Spin off company will be owner
Hydrometallurgical recycling of catalysts <sup>5</sup>	Recovery of Lanthanum, Cerium, Palladium, Platinum, Rhodium, Tungsten, Rhenium and Diatomite	Recycling	The research and development of recovery of materials is planned for 2015	A patent is planned for the process after the research and development work	Spin off company will be owner
Hydrometallurgical recycling of capacitors <sup>5</sup>	Recovery of Antimony, Niobium, Tantalum and PGM materials	Recycling	The research and development of recovery of materials is planned for 2015	A patent is planned for the process after the research and development work	Spin off company will be owner
Hydrometallurgical recycling of LED, WLED and OLED <sup>5</sup>	Recovery of Gallium and Indium	Recycling	The research and development of recovery of materials is planned for 2018	A patent is planned for the process after the research and development work	Spin off company will be owner

### Hydrometallurgical Recycling of Lithium Batteries:

- Purpose: Recycling of Lithium-ion batteries.
- Potential exploitation of the foreground, when and by whom:  
The results achieved within HydroWEEE allow defining the hydrometallurgical route for the recovery of lithium and cobalt from Lithium-ion batteries (ready by the end of the project). The new founded spin off company will be able to exploit this foreground.
- IPR exploitable measures taken or intended:  
Patent is not foreseen
- Further research:  
It will not be possible within HydroWEEE project to assess the pre-treatment of lithium ion batteries, in order to produce the ground electrodic material (rich in lithium and cobalt, treated in the hydrometallurgical process) at an industrial scale, due to explosion risk during grinding. Further grants will be searched for the development of batteries pre-treatment.
- Potential/expected impact:  
The expected impact is very high due to both the fast growth of the Battery market and the increase of metal prices.

### Hydrometallurgical Recycling of Fluorescent powders:

- Purpose: Recycling of fluorescent powders coming from CRT and lamps.
- Potential exploitation of the foreground, when and by whom:  
The technology for the production of such powders is well known and already applied by one of the beneficiaries (Relight). The results achieved within HydroWEEE allow defining the hydrometallurgical route for the recovery of yttrium and zinc from the powders (ready by the end of the project), that at the moment are disposed as hazardous waste. The new founded spin off company will be able to exploit this foreground.
- IPR exploitable measures taken or intended:  
Patent is in progress.
- Further research:  
Possible risks are related to yttrium and zinc purities, so there could be a necessary further research.
- Potential/expected impact:  
The expected impact is high due to both the fast growth of the WEEE market and the increase of metal prices.

#### Hydrometallurgical Recycling of panels from LCD wastes:

- Purpose: Recycling of the panel coming from LCD wastes.
- Potential exploitation of the foreground, when and by whom:  
The results achieved within HydroWEEE allow defining the hydrometallurgical route for the recovery of indium from the shredded panels. The new founded spin off company will be able to exploit this foreground.
- IPR exploitable measures taken or intended:  
Patent is in progress.
- Further research:  
Further research is necessary both for the panel shredding optimization and for indium purity enhancement. These issues are considered necessary before an effective exploitation.
- Potential/expected impact:  
The expected impact is high due to both the fast growth of the LCD market and the increase of metal prices.

#### Hydrometallurgical Recycling of PCBs and other electronic scraps:

- Purpose: Recycling of PCBs and other electronic scraps.
- Potential exploitation of the foreground, when and by whom:  
The results achieved within HydroWEEE allow defining the hydrometallurgical route for the recovery of copper and other metals from PCBs. The new founded spin off company will be able to exploit this foreground.
- IPR exploitable measures taken or intended:  
Patent is in progress.
- Further research:  
There are fine adjustments of process in pilot scale and possible change in plant operation, so further research will be necessary.
- Potential/expected impact:  
The expected impact is high due to both the fast growth of the WEEE market and the increase of metal prices.