"Turning waste into a resource through innovative technologies, processes and services" (7th Framework Programme)

# CoLaBATS+−

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this issue



## Project Update:

The project has reached an exciting milestone, with the completion of the TSIL and green chemistry selection. This allows for work to be undertaken on the development and building of the pilot plant. The proposed development of the unit employs well developed technologies and processes with novel applications and uses.

It is from this point that the consortium's hard work becomes a physical entity, as the pilot unit is built, and leads on to the second part of the project. This will develop the process and quantify the environmental and economic incentives and benefits of the process and technology.

Over the next six months, the consortium will host a workshop at City Hall in London (November 2015, for more details see www.colabats.eu), scale-up the prototype and begin production of the pilot plant. This is all with the final milestone in sight – pilot demonstration.

The final year of the CoLaBATS project will be a dynamic time and excitement mounts to see the novel process in operation. The timing of the project conveniently aligns itself with the EU Batteries and Accumulators Directive, which is pushing the recycling thresholds higher. The CoLaBATS aim is to aid industry to achieve these battery recycling targets.

## CoLaBATS Consortium Members

## Editorial:

This newsletter aligns with the project's 2 year milestone. Throughout the two years, a lot of novel innovations have been achieved. These include the chemistries and techniques developed for obtaining battery black mass (dismantling and separation techniques), deep eutectic solvents for efficient dissolution of the waste material, and the choice of task specific ionic liquids (TSILs) to produce separated metal fractions, appropriate for high grade metal recovery (through methods such as electrodeposition etc.).

The third of the project is focussed on demonstrating the newly developed chemistry. This will involve pilot scale treatment of small batches of battery material with the objective of recovering saleable fractions.

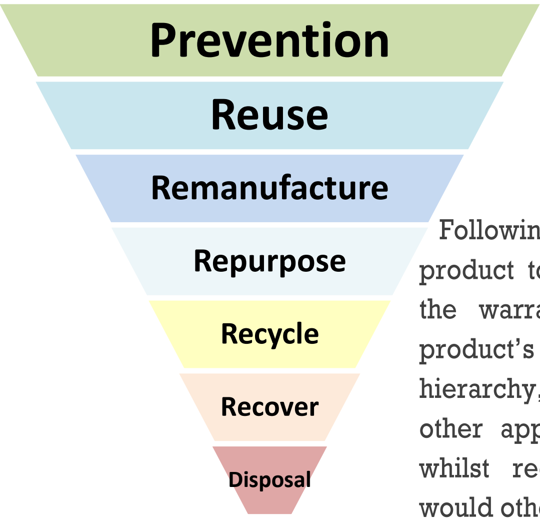
# Sustainability and the Circular Economy

## "Sustainability; social, environmental and economic processes that do not deplete resources"

Ideas about sustainability are very popular with governments and the European Commission, encouraging design for reuse, remanufacturing, repurposing and recycling, and further fuel the push for developing a circular economy.

### Circular Economy

The circular economy ethos is to develop and manufacture objects, processes and concepts that prevent resources from becoming obsolete. The premise of the idea is to allow continued use of products or resources through mechanisms such as reuse, remanufacturing and repurposing. Limiting obsolescence can retain value in materials and products, limit disposal impacts (landfill, incineration and associated $CO_2$ emissions and environmental damage), and secure supply chains in countries and regions that do not have some natural resources.




To develop a circular economy, products and services should be designed with the waste hierarchy in mind. The most value is retained within a product when it is reused.

Following this, remanufacturing (returning the product to its original quality (as-new) – including the warranty) can retain a large amount of a product's residual value. Continuing down the waste hierarchy, reutilisation of components or parts for other applications (repurposing) can retain value whilst reducing the environmental impacts that would otherwise be created from manufacturing new products/parts. Lastly, recycling of materials can reduce the impact of mining/collecting/generating new resources and creates large environmental and societal impact savings. Beyond recycling is energy recovery, which uses waste as a fuel and captures energy for electricity production.

### Batteries and Sustainability

The batteries market is currently experiencing growth, thanks to governments supporting hybrid and electric vehicle production and use. By 2020, it is estimated that the global Li battery market will be approximately 14 billion Euros. This growth in manufacturing and demand requires resources sourced from around the world, and in countries with political or ethical difficulties. Thus, for Europe, obtaining rare earth elements, cobalt and many other materials may become more expensive and restricted in the future. Thus, it is imperative for batteries to be developed for a circular economy and with the waste hierarchy in mind.

For batteries, value can be retained by remanufacturing battery packs – replacing faulty or dead cells, raising the power production to as-new.

## Circular Economy & Sustainable Processes

**Power tools with interchangeable battery packs:** - to eliminate the need for multiple battery packs and charging equipment DIY tool manufacturers are now designing their hand tools to share one battery pack. Thus, at the end-of-life, less materials are sent for recycling. (Prevention)

**Renting:** - Equipment and product rentals are becoming more popular for environmental, economic and social reasons. Renting equipment can provide people who cannot afford to buy the products access to the same services (e.g. car sharing), or for people who do not have the space to store products (e.g. tool hire – cement mixer). And for those wanting products for onetime events (fashion rentals - handbags, wedding dresses, jeans, etc).

**Engine Remanufacturing:** - Often vehicle engines fail due to a small number of failures with individual parts, rendering the entire engine to be broken. Therefore, a large proportion of the materials can be cleaned and used as part of a remanufactured unit (as-good-as new).

Beyond repairing and remanufacturing batteries, new research developments are massaging the power supplied by old battery packs to supply energy to less critical, lower power applications. Finally, recycling of critical and valuable metals within batteries can reduce supply pressures (and costs), and limit pathways for heavy metals to enter the environment.

Whilst both hydro- and pyro-metallurgical processes have been developed for battery recycling (e.g. Umicore, Recupyl), these processes concentrate on capturing the most abundant and valuable materials within the batteries (primarily cobalt). CoLaBATS differs from these current applications by selectively retrieving multiple metals from the battery waste – including those which are considered critical (lanthanides) to the European Union.

Additionally, the CoLaBATS technology utilises novel green chemistries which are more environmentally benign compared to current hydrometallurgical processes and consume less energy compared to pyrometallurgical units. However, to fully assess the sustainability of the CoLaBATS technology and green chemistry processes, a Life Cycle Assessment (LCA) will be conducted. As described on the right, an LCA can be conducted in various fashions, in order to assess the environmental impacts arising from a process, product or design. For the CoLaBATS technology, a gate-to-gate life cycle impact assessment (LCIA) will be conducted.

## Attributes of Conducting a LCA

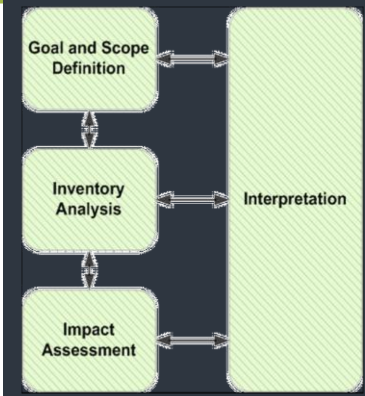
An LCA addresses the consumption and use of resources, and environmental pressure and burden placed upon the earth for a particular process or product. This will allow all chemistries used in CoLaBATS to be addressed along with identification of areas which can be improved (efficiency, innovation and cost), and causes of significant environmental impact (to be replaced). This will allow the integration of environmental management as a major business aspect, and will focus on improving the return of investment.

## Limitations of Results/Assessment

Whilst the impacts arising from the LCA consider impacts upon global warming potential, acidification and eutrophication, as well as human toxicity impacts, the results are not well suited to local and regional societal impacts, as well as economics. Thus, topics such as infrastructure burden, traffic density, and job security are not considered. Additionally, LCA only considers part of environmental impacts, and thus may neglect major impacts provided by CoLaBATS technology.

## Impact of Assessment for CoLaBATS

For the CoLaBATS technology, a LCA will provide a comparison of the sustainable impacts of this technology to that of hydro- and pyro-metallurgical designs and equipment operation. This is imperative to understand the benefits that CoLaBATS can supply in comparison to conventional processes and treatments, and how new EU legislation and recycling targets for batteries can be reached.




Source: Wikipedia 2015

### Cradle to Grave

Representing the life cycle from obtaining the raw materials to the disposal/end-of-life (disposal). This phrase is now often replaced by cradle-to-cradle, which represents the life time of the product until it is disposed of and begins its pathway for use in a new product.

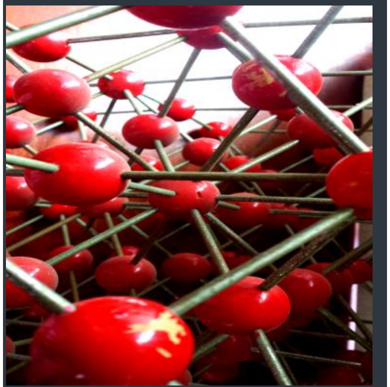
### Cradle to Cradle

Identifying the resources used to create a product or process all the way through its life – supply, manufacturing, use, and onwards to reuse or remanufacturing.

### Gate to Gate (simplified)

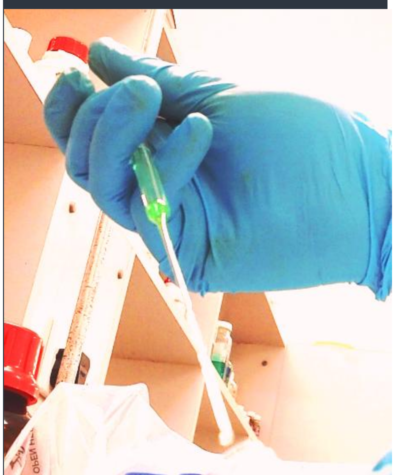
This application of an LCA uses only raw materials, resources and outputs that are used and generated within a defined process. For example, the CoLaBATS project will utilise this type of impact assessment, identifying the impacts arising from only the pilot plant operation. Therefore, no impact of the pilot plant tools and equipment manufacturing, or battery production will be included. Only the impacts of the physical and chemical processes used to treat batteries, and the outputs arising from these actions (metal solutions, slags, waste chemistries etc) will be defined within the LCIA.

**The Materials Group at the University of Leicester (UoL) are the pioneers of the Deep Eutectic Solvent (DES) technology that has grown in popularity and application over recent years.**



DESs are a group of ionic solvents that exhibit similar properties to Ionic Liquids but which are tuneable, by compositional formulation, over a wide range of rheological (viscosity, conductivity) and chemical properties. Whilst DES and ionic liquids share similar properties and capabilities, DESs have generated a huge amount of interest over recent years due to a number of more desirable qualities that they display. They are air and moisture insensitive, have wide electrochemical windows, high solubilities of metal salts, are made from inexpensive and renewable feed stocks, are user friendly and have lower environmental impact. The Materials Group (UoL) is currently housed in our own dedicated building (main Campus) where we have a team of over 40 academics, post docs and PhD students. Here we have a range of facilities available such as dedicated microscopy suite, material testing and thermal analysis suite as well as a pilot plant scale up room where processes can be fully scaled up from small scale laboratory testing to ~ 60 L.


Prof. Karl Ryder has been working in the field of DESs for more than a decade now and his current interests are primarily focussed on developing electrochemical processes for modifying a range of metallic surfaces and also developing novel polymer batteries. Much of the surface modification work has revolved around the electroplating and electropolishing of a wide variety of real world substrates with the aim of replacing current processes already used by industry. His current main focuses range from developing a replacement hard chrome plating from trivalent ($Cr^{3+}$) Cr salts instead of using hexavalent Cr sources, electrochemical processing of internal and external surfaces of single crystal superalloy aerospace turbine castings and novel solder fluxes for a range of electronics industry processes. Each of these activities is currently in the process of scale up development with various industrial partners across Europe, with volumes of DES being used in excess of 1000 L at this stage. Other interests within the DES group at the University of Leicester are also found in recycling/recovery of rare earth/precious metals from ores and scrap materials and also forensic science where DESs have been employed to help develop finger prints.



# CLEANER SOLVENTS FOR SUSTAINABLE CHEMISTRY

Solvionic

## TECHNOLOGY

Within the framework of sustainable development, Solvionic develops selective chemistry branching from the use of ionic liquids.

Solvionic is actively engaged in the production of ionic liquids, the development of their applications and providing assistance to industrial projects in the field of energy storage, new materials and catalysis.

Solvionic is also the choice for a privileged partnership offering dynamism, reactivity and competitiveness.

Innovation, high-tech control and quality of the products are the key factors to Solvionic's success today and Solvionic products and services are being marketed worldwide.

## SERVICES

### PRODUCTION

Solvionic produces more than 100 ionic liquids and related products references. Different quality standards are available depending on application. Volumes are adapted to every step of a process i.e. from few grams to the ton scale.

### CUSTOM SYNTHESIS

Solvionic provides individual services according to customers' specifications and needs.

### RESEARCH & DEVELOPMENT

New products and solutions are designed under co-development contracts with companies looking for enhancement and novelty for their materials and processes.

## APPLICATIONS

| PRODUCTION | SYNTHESIS & CATALYSIS | SEPARATION & EXTRACTION |
|---|---|---|
| >Electrodeposition<br>>Anti-Migration<br>>Electrochromic devices<br>>Lubricants<br>>Antistatic<br>>Cleaning & Degreasing | >Organic Reaction<br>>Intensification processes µreactors<br>>Immobilisation of catalyst<br>>Nanoparticles synthesis for catalysis | >Liquid-Liquid extraction<br>>Nuclear waste treatment<br>>Desulfuration of diesel<br>>Metal extraction<br>>Gases purification |
| **ENERGY STORAGE** | **BIOTECNOLOGY** | **ANALYTICS** |
| >Supercapacitors<br>>Li Batteries<br>>Solar cells<br>>Fuel cells | >Biomass conversion<br>>Protein purification<br>>Enzymatic | >Mass spectroscopy matrices<br>>Chromatography<br>>Karl Fisher |

## Other UK & EU Funded Battery Projects:

ABACUS – innovative Business models and design Approaches for extending the in-serviCE battery life of fUture low carbon vehicleS.

A UK government funded project to develop a circular economy for electric vehicle batteries, trough service design (modularity), reuse, remanufacturing and secondary applications, whilst meeting auto-motive targets.

ELIBAMA: European Li-Ion Battery Advanced MAnufacturing –

This is a European Commission funded project to develop a centre of excellence for the European automotive battery industry, with particular interest in Li-ion cell and battery pack production for electric

Env-Aqua Solutions

# Upcoming Milestones & Events:

## CoLaBATS

| | |
|---|---|
| **Milestone 4** | Scale-up to prototype |
| **Milestone 5** | Demonstration |

## Coming Soon:

The CoLaBATS project will be running further dissemination events, coinciding with the completion of the technology. These events will be announced in the newsletter, and on the website (www.colabats.eu) and will include a final demonstration of the CoLaBATS achievements to be hosted in Spain, and a final workshop for industry experts.

## Event - CoLaBATS workshop 16/11/15

The CoLaBATS project will be holding a battery recycling workshop at an event focused on the Recovery of Energy and Propulsion Systems (REPS); working towards a circular economy. The day will consist of presentations by international leading experts, including a vehicle battery expert from Ricardo and Michael Green, a battery legislative expert. The day will include updates about the CoLaBATS project, developed pilot technology and a workshop session exploring the future of battery recycling and materials recovery.

**16TH November, City Hall, London**

## Useful Links:

- CoLaBATS – http://www.colabats.eu
- ELIBAMA - https://elibama.wordpress.com/
- HSSMI - http://hssmi.org/research-themes/manufacture-electric-powertrains/
- Ellen MacArthur Foundation - http://www.ellenmacarthurfoundation.org/circular-economy
- Advanced Propulsion Centre - http://www.apcuk.co.uk/

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