

*Impact
&
Opportunity*

Exploring Raw Material
Insights and Industrial
Prospects

Deep Eutectic Solvents
Applications in Metallurgy.
Perspectives & Challenges

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EU - H2020



C R O C O D I L E

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MEMBER OF BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

ION4RAW Exploitation Workshop - Online - 30 November 2023







Learnings from the CROCODILE project Success Story

This project has received funding from the European Union's EU Framework Programme for Research and Innovation Horizon 2020 under Grant Agreement No 776473 - <https://h2020-crocodile.eu/>

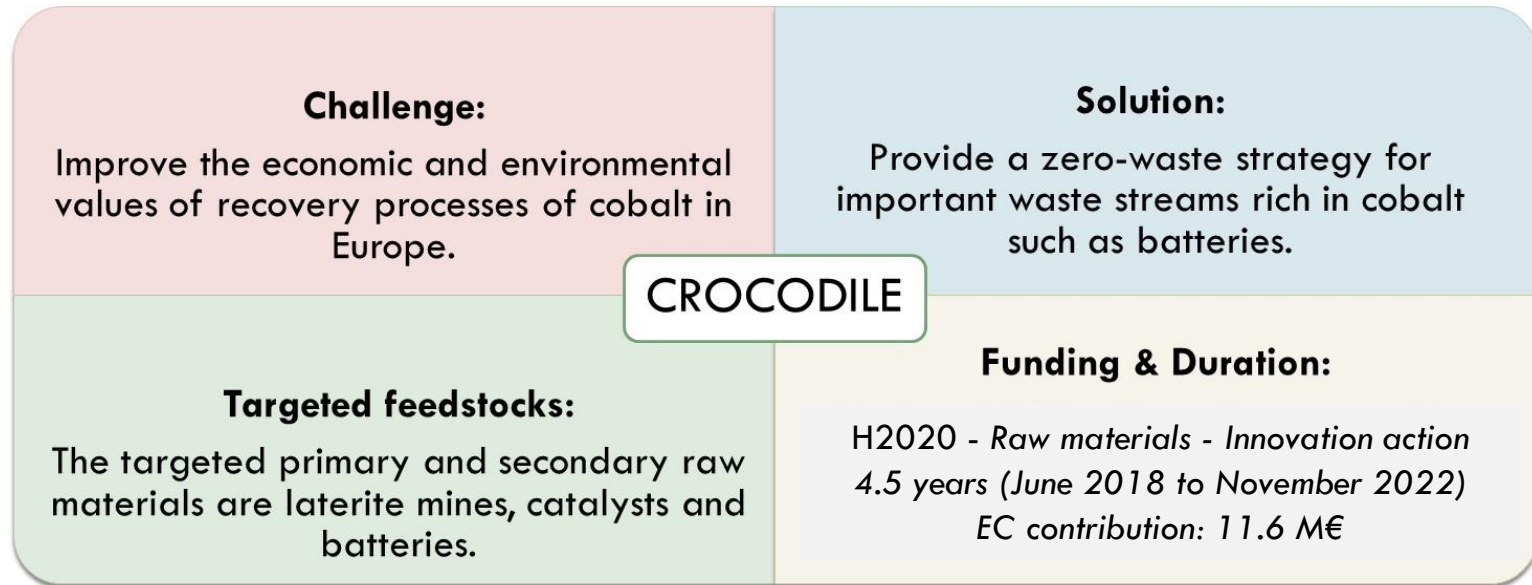


Outline

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	General information
	The Crocodile concept
	The lab research
	LCA/LCC
	Pilot Validation
	Conclusions

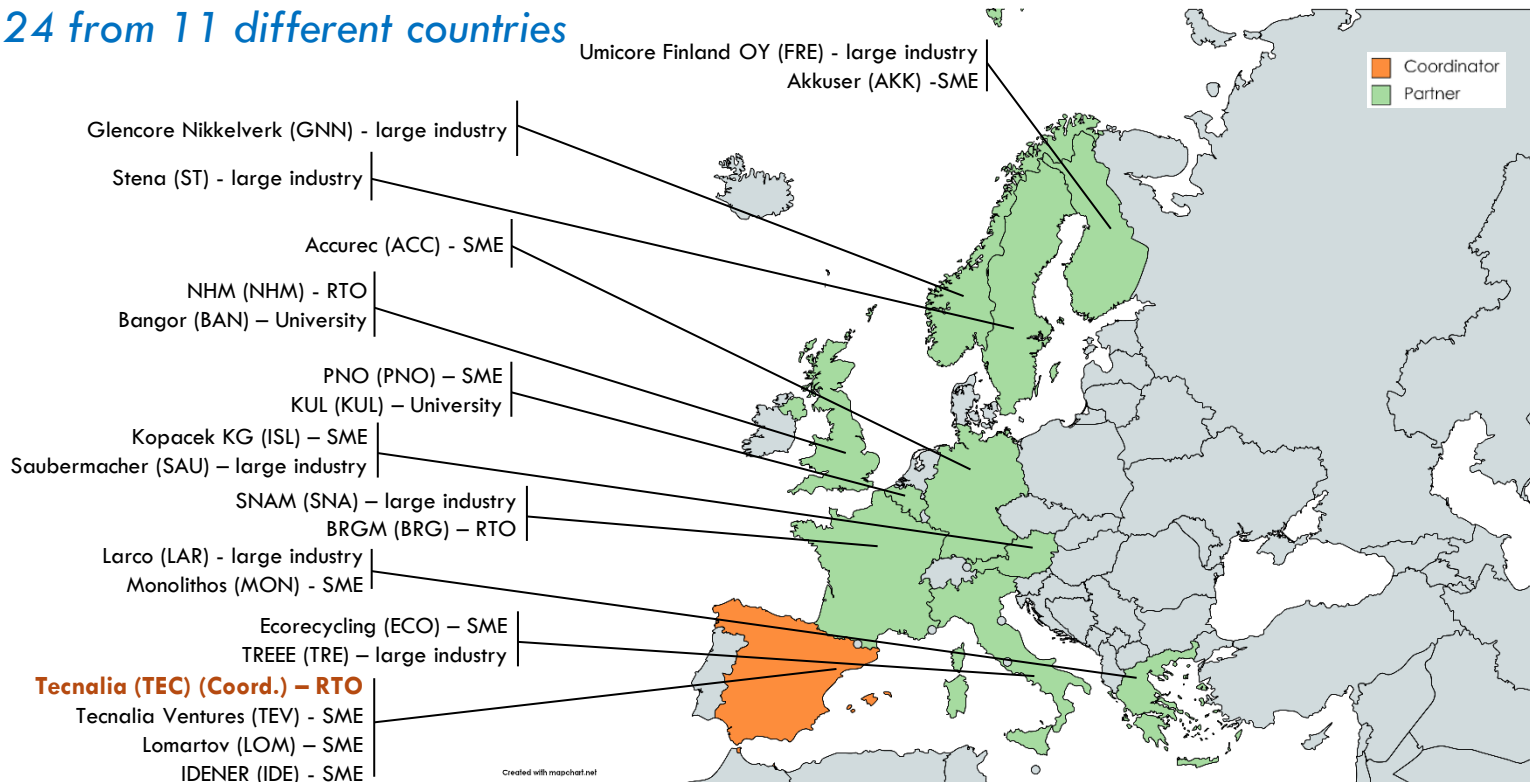
First of a kind commercial Compact system for the efficient Recovery Of CObalt Designed with novel Integrated LEading technologies



General information

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Partners: 24 from 11 different countries



The CROCODILE concept

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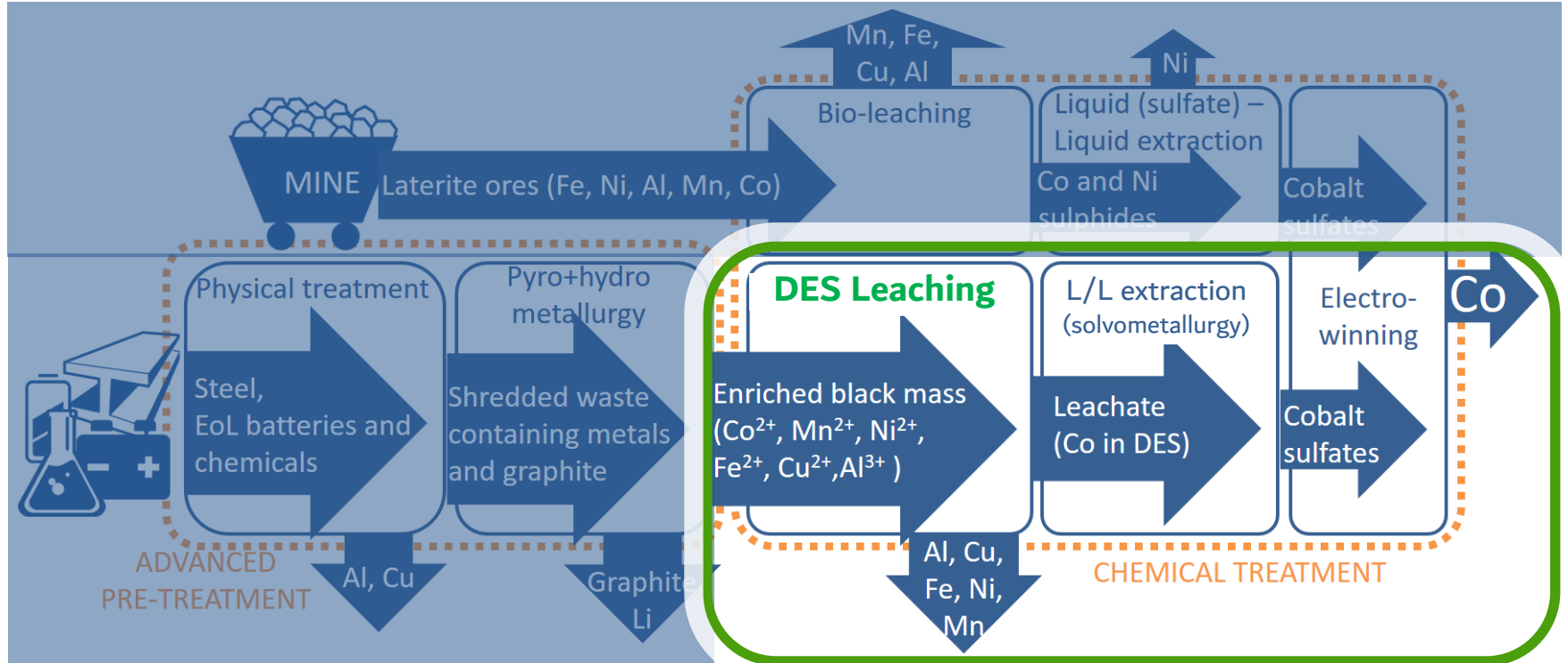
Current SoA is mainly driven by pyrometallurgy / hydrometallurgy

- High energetic cost
- Use of strong inorganic acids such as sulfuric and hydrochloric acids
- High environmental impact
- Not all metals are recovered from batteries
- High generation of waste (slag and gas emissions)
- High CAPEX



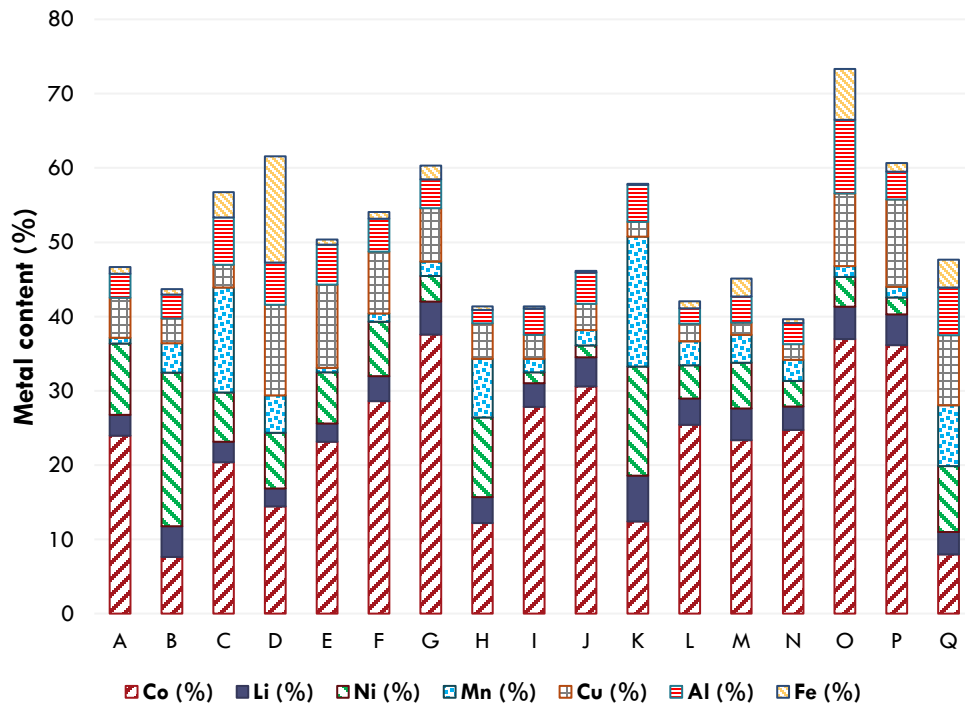
The CROCODILE concept

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The lab research: material

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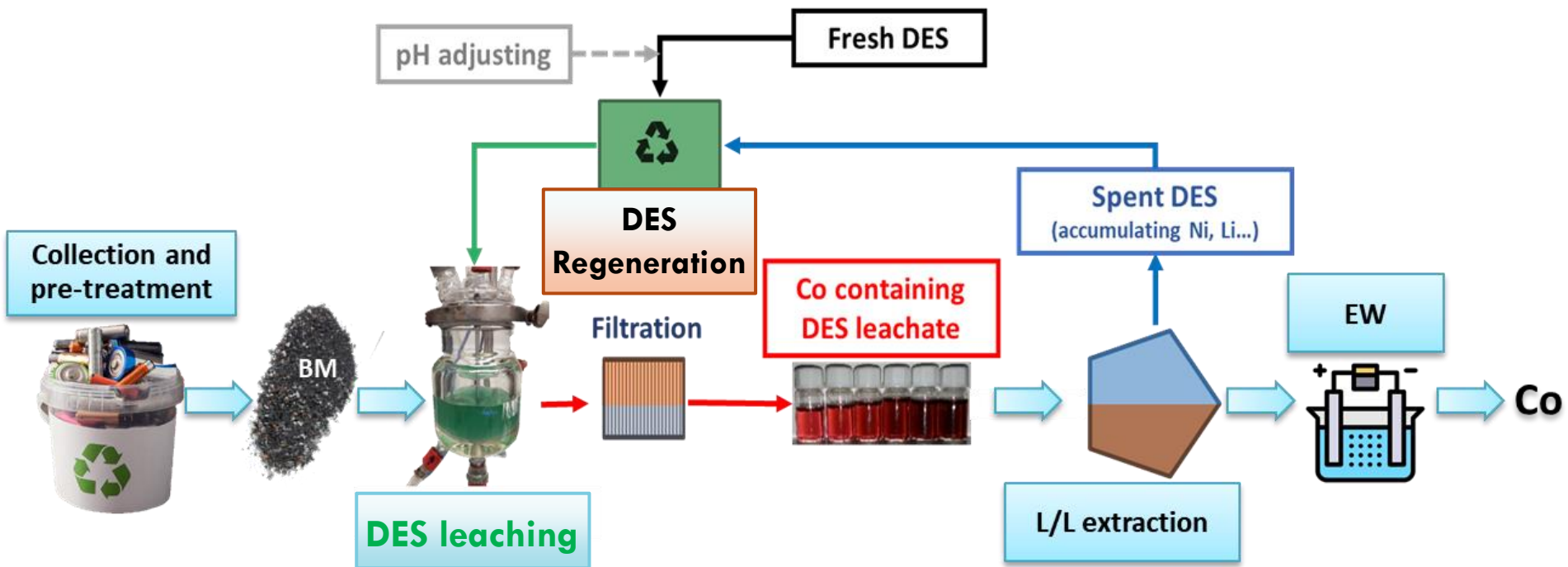


Broad type of Black mass samples studied

Metal	Content range (%)
Co	8-38%
Li	2-6%
Ni	1-21%
Mn	1-17%

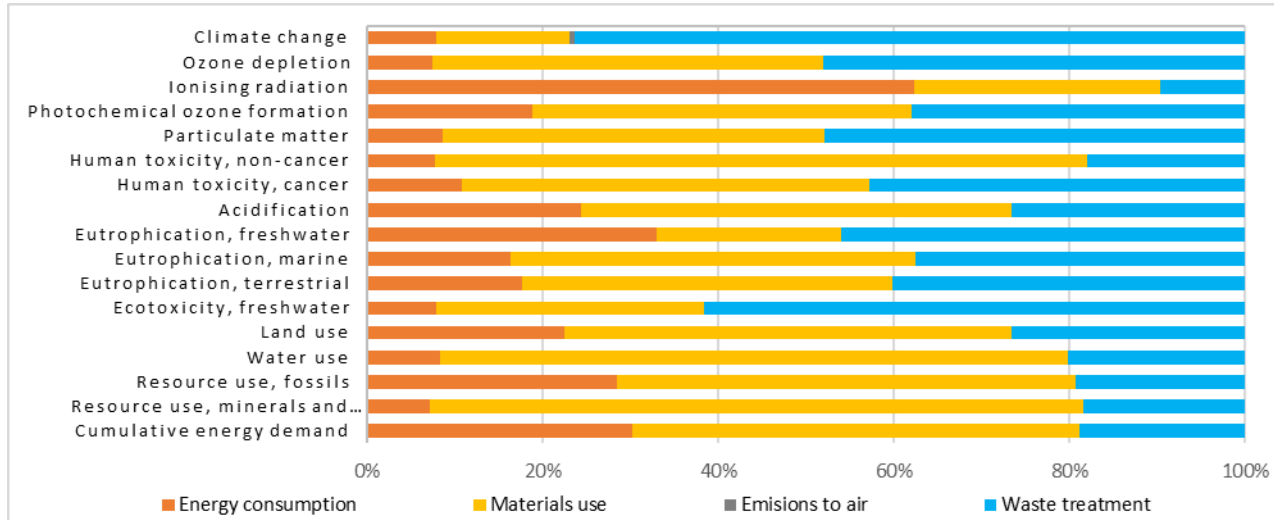
The lab research: flow-sheet developed

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LCA

- A methodology that takes into account the health, safety and environmental risks.
- Environment assessment of the individual R&D technologies to select the best performing scenarios
- Modelling and assessment of the pilot unit



Product Environment Footprint (PEF) impact categories (17) for the sources of impact (4): CROCODILE pilot LCA results

LCA & LCC

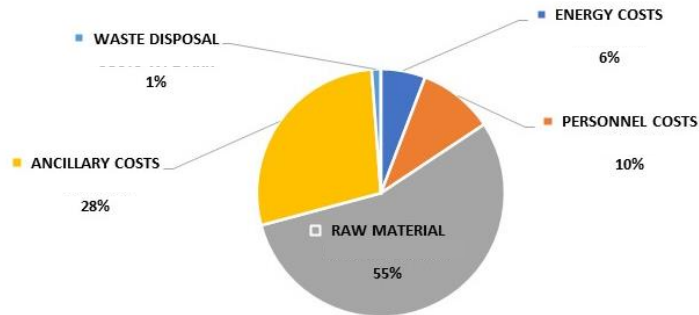
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LCC

Economic assesment of all the technologies involved: pretreatment and chemical processes

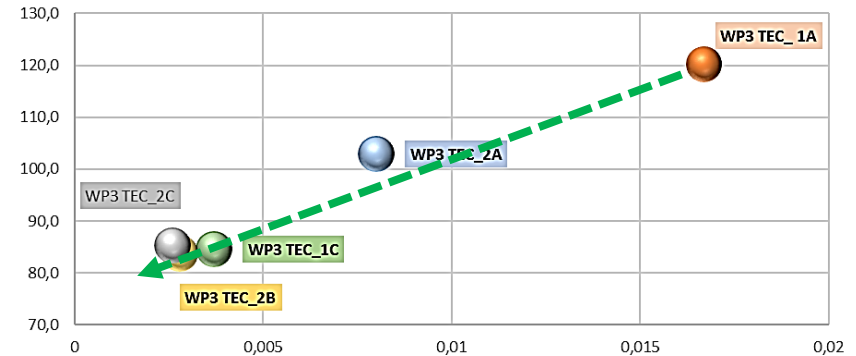
Integrating environment and economic data

Breakdown structure OPEX costs



Pretreatment

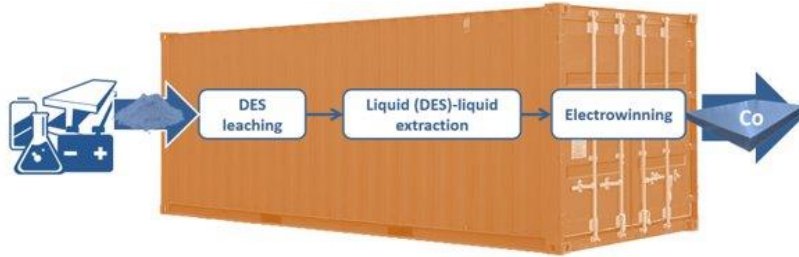
LCA/LCC SUMMARY OF TEC TECHNOLOGIES



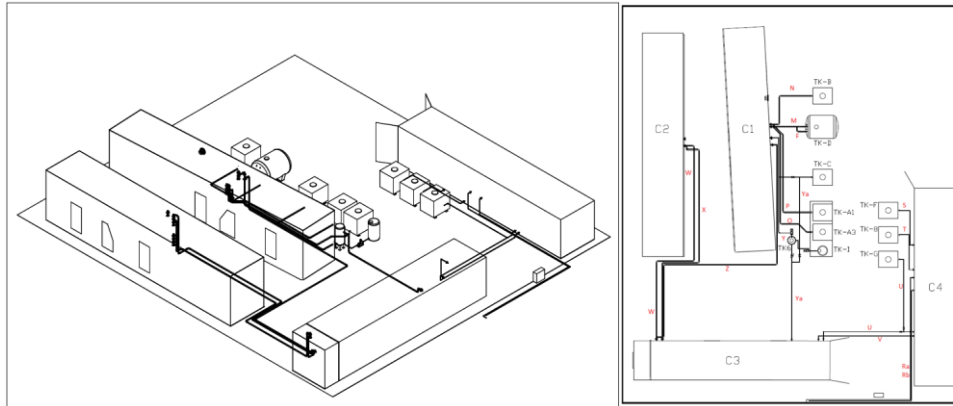
Leaching process

Validation of the technology in the pilot

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- Mobile Pilot design: basic and detailed engineering
- Pilot construction: 4 containers
- Validation in the pilot:
1000 kg BM (25% Co content) tested



- Final layout definition

Validation of the technology in the pilot

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Production: > 6 kg Co metal/day
Cobalt purity: > 97 %



Conclusions

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- ❖ A sustainable approach for the valorization of black mass generated from the pre-treatment of lithium-ion batteries was established. The recycling route uses a hydrometallurgical process composed of **leaching with DES (Deep Eutectic Solvents)**, solvent extraction and electrolysis, in order to recover **metallic cobalt**.
- ❖ The novel and innovative process developed has been validated in a **pilot** built for that purpose, showing strong **potential for its implementation at industrial scale**. The cobalt recovered can be used as feed in several fields as catalysts, alloys and precursor for the production of lithium-ion batteries.
- ❖ Several scenarios have been analysed from the **economic** point of view: the **profitability** of the “CROCODILE route” varies a lot depending on the plant size (input volume of black mass to be treated).
- ❖ In addition, the following aspects showed essential influence on the profitability of the CROCODILE pilot plant:
 - *the cobalt content in the black mass,*
 - *the market price for the cobalt metal*
 - *the cost of the black mass*
 - *the potential valorization of other valuable products such as **nickel / lithium / manganese** derivatives and **graphite**, existing as subproducts in the process.*
- ❖ Since the deployment of the recycling industry is developing slower than the European battery industry, there is an opportunity for this **DES based CROCODILE technology** to be further optimized and to be used as one of the main recycling technologies in the European market as an alternative to existing Co recovery industrial processes, **contributing** to both a greener future and make **Europe independent** from other markets, such as that of China.

Learnings from the CROCODILE project Success Story



<http://h2020-crocodile.eu/>

Thank you for your attention

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