



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

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/>

Nader Akil

2<sup>nd</sup> EU Critical Raw Materials Event, Brussels, 12 November 2018



# Outline



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Created by hunotika  
from Noun Project

Why cobalt?  
Supply, demand & use of cobalt



Created by shigel  
from Noun Project

Importance of cobalt recovery for the EU Economy



The Crocodile project: its aim, activities and expected benefits

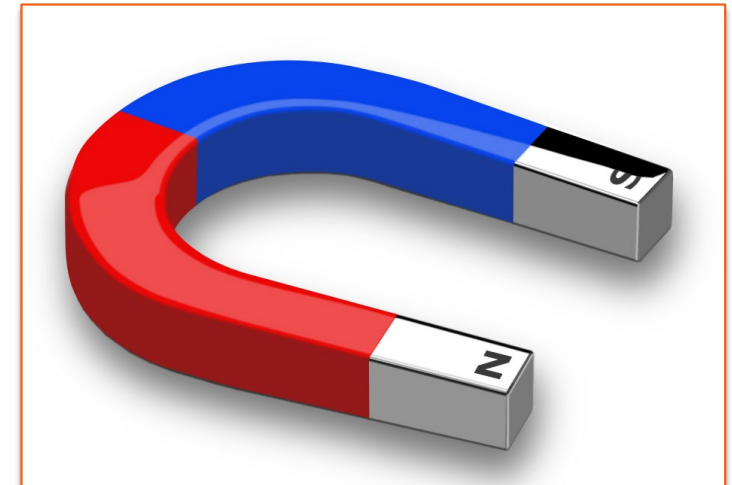
# Why cobalt?

## = Critical Raw Material (CRM)

- Exceptional high-temperature strength, corrosion-resistance, catalytic properties,
- Exceptional strengths for electrochemical properties: crucial element for high performance applications (e.g. jet engines and electrical power generation turbines, high strength steel, super alloys, samarium cobalt magnets, catalysts, pigments, tires, etc.).
- Increasing demand



<https://cosmosmagazine.com/technology/how-does-a-jet-engine-work>

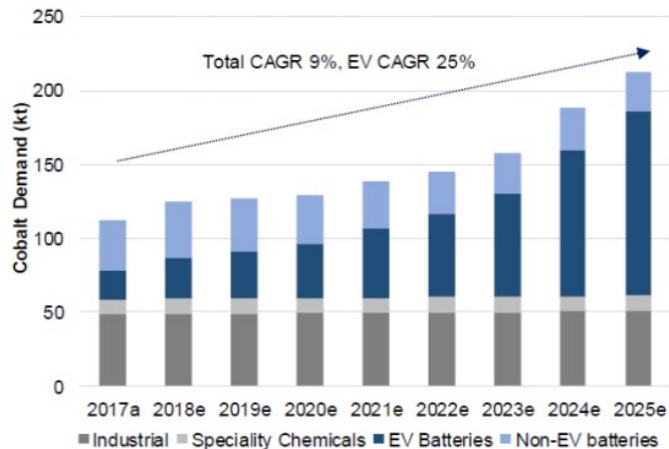


<http://wtamu.edu/~cbaird/sq/2013/03/26/how-do-magnets-work/>

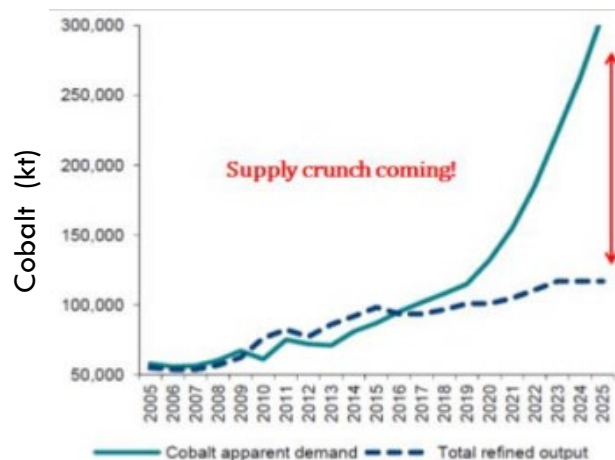
# Supply, demand & use of cobalt

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## Rising demand, deficit and price:



Demand for cobalt is expected to soar with the growth of LIB, particularly EV batteries  
Source: CANACCORD Genuity report, May 2018



Large deficit in cobalt supply and demand is expected in the coming few years. Source: Exane BNP Paribas



Cobalt price increased by ~ 250% in 2017- between the submission and approval of CROCODILE!

- Batteries: about 50% of the overall current cobalt demand worldwide (estimated at more than 100k ton annually) is related to the production of lithium-ion battery (LIB) cathodes.
- By 2020, the cobalt demand in battery applications alone could be greater than the entire world market for refined cobalt in 2015.
- Cobalt price has risen nearly 250% in the 2017 and is expected to significantly increase in the coming years, driven by stricter emissions controls that push global demand for electric vehicles.

# Importance of cobalt recovery for the EU Economy



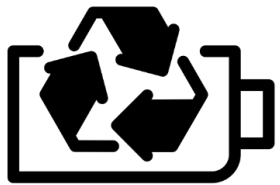
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## Supply risk!

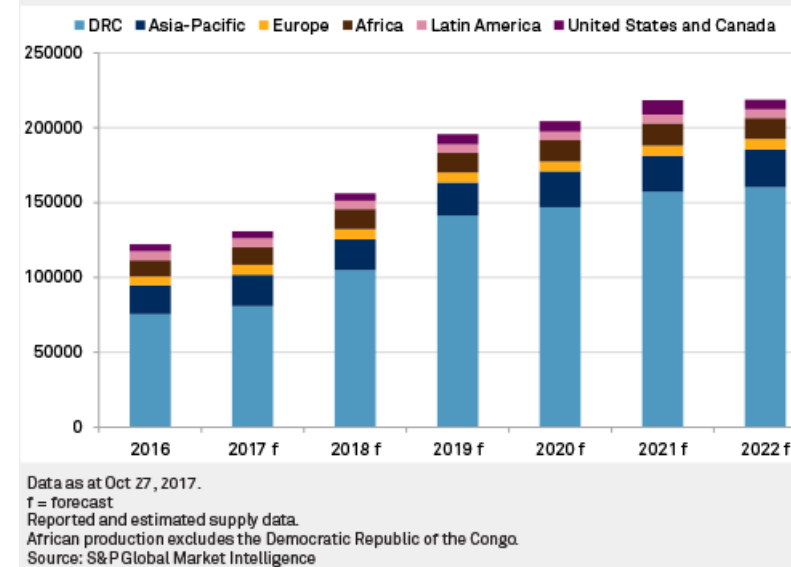
- **Primary** production = 65% (approx. 10,000 tons/year).  
= Imported from geopolitically unstable countries such as Democratic Republic of the Congo (DRC), Zambia or Central African Republic.



- **Secondary** production = 35%.  
= Mainly from recovered from spent batteries, superalloys and hard metals.

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Global cobalt production by region, 2016-2022 (Tonnes)



# The Crocodile project



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First of a kind commercial Compact system for the efficient Recovery Of CObalt Designed with novel Integrated LEading technologies <http://h2020-crocodile.eu/>

## Challenge:

Improve the economic and environmental values of recovery processes of cobalt in Europe.

## Solution:

Provide a zero-waste strategy for important waste streams rich in cobalt such as batteries.

CROCODILE

## Targeted feedstocks:

The targeted primary and secondary raw materials are laterite mines, autocatalysts and batteries.

## Funding & Duration:



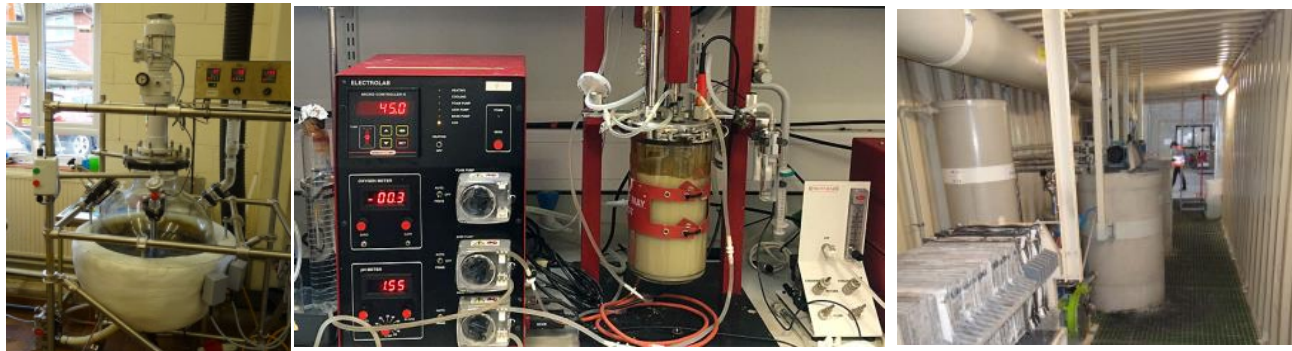
Horizon 2020 - Grant Agreement No. 776473- EC contribution: 11 625 289€  
4 years: from June 2018 to May 2022



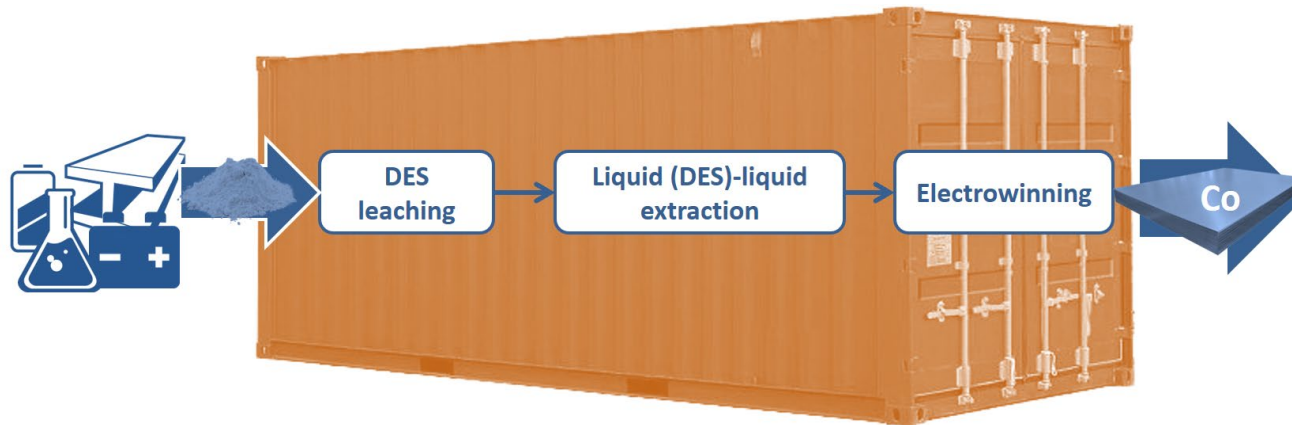
# The Crocodile objectives



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DES Leaching reactor at Tecnalia (left), Bioleaching experiments with COG3 samples conducted by COG3 partner Acidophile Research Team at Bangor University (center) and the EcoRecycling mobile plant (right)



CROCODILE mobile solution overview


- Demonstrate **scaled-up** innovative integrated systems and technologies capable of enhancing the efficiency of existing raw materials recovery processes;
- Develop a **new mobile system** with the capability of producing cobalt metal to enable new business opportunities and expand the business across the EU;
- Build a **strong value chain** capable of supplying approx. 10,000 ton of cobalt per year (about 65% of the current EU demand) from mainly European resources.

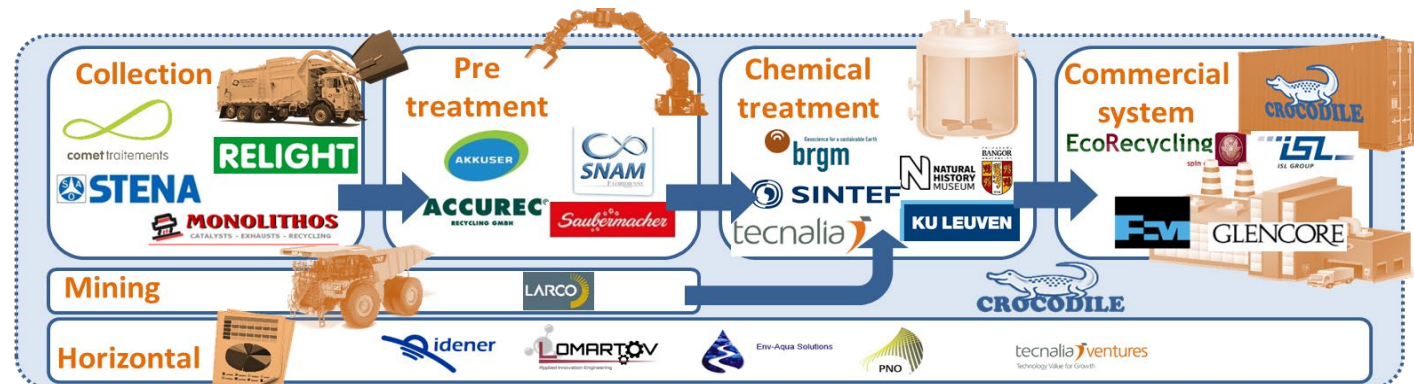
# The Crocodile consortium



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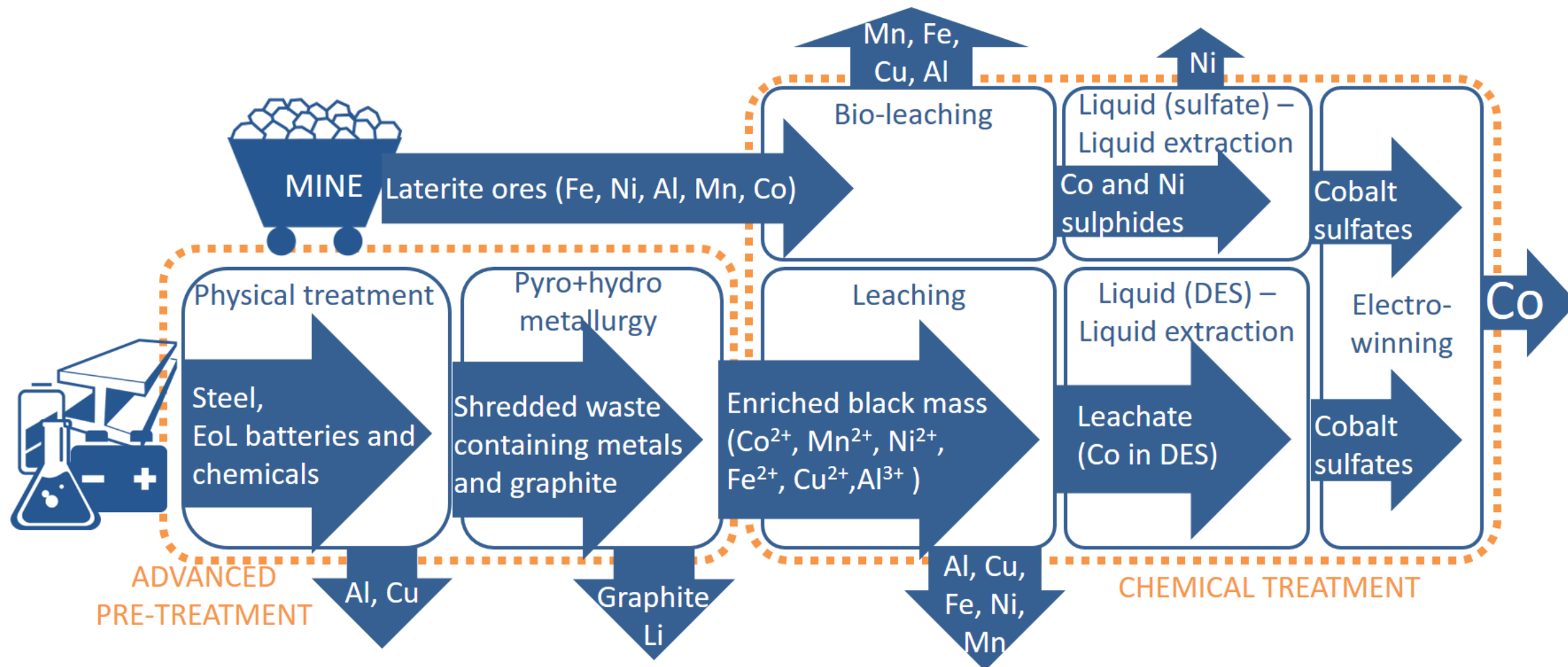


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<http://h2020-crocodile.eu/>





# The Crocodile project



# The Crocodile project activities (1 / 2)

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- Build a commercial compact mobile system with a capacity of up to 200kg of cobalt metal per day-65ton/year;
- Optimise the pretreatment step of secondary waste rich in cobalt by advanced mechanical, wet mechanical process and pyrometallurgy;
- Fine-tune the recovery process, from economic and environmental point of view, designed in a closed-loop set up, reducing OPEX and waste generation.

# The Crocodile project activities (2/2)

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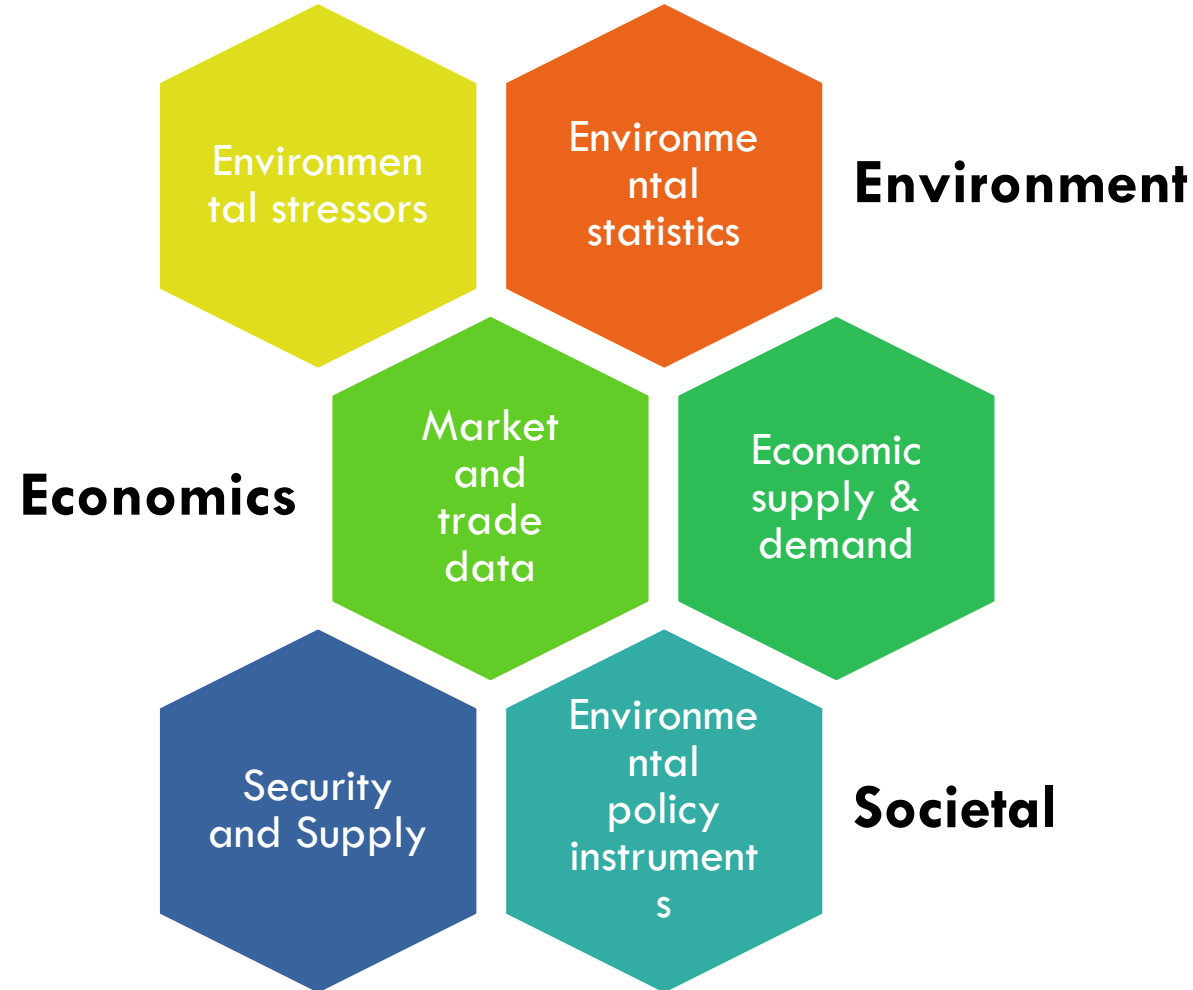
- Scale up the bio-processing route for primary resources;
- Develop a detailed market analysis and business models based on process efficiency, metal stock exchange and market share, and an engagement strategy with investors;
- Engage with civil society to obtain a social license to operate and to co-develop the CROCODILE solution.

# Life Cycle Assessment

- A methodology that takes into account the health, safety and environmental risks.
- Addressing REACH, RoHS and local environmental standards.
- Modelling of the pilot unit and design.
- Economic and environmental assessment of the pilot unit.

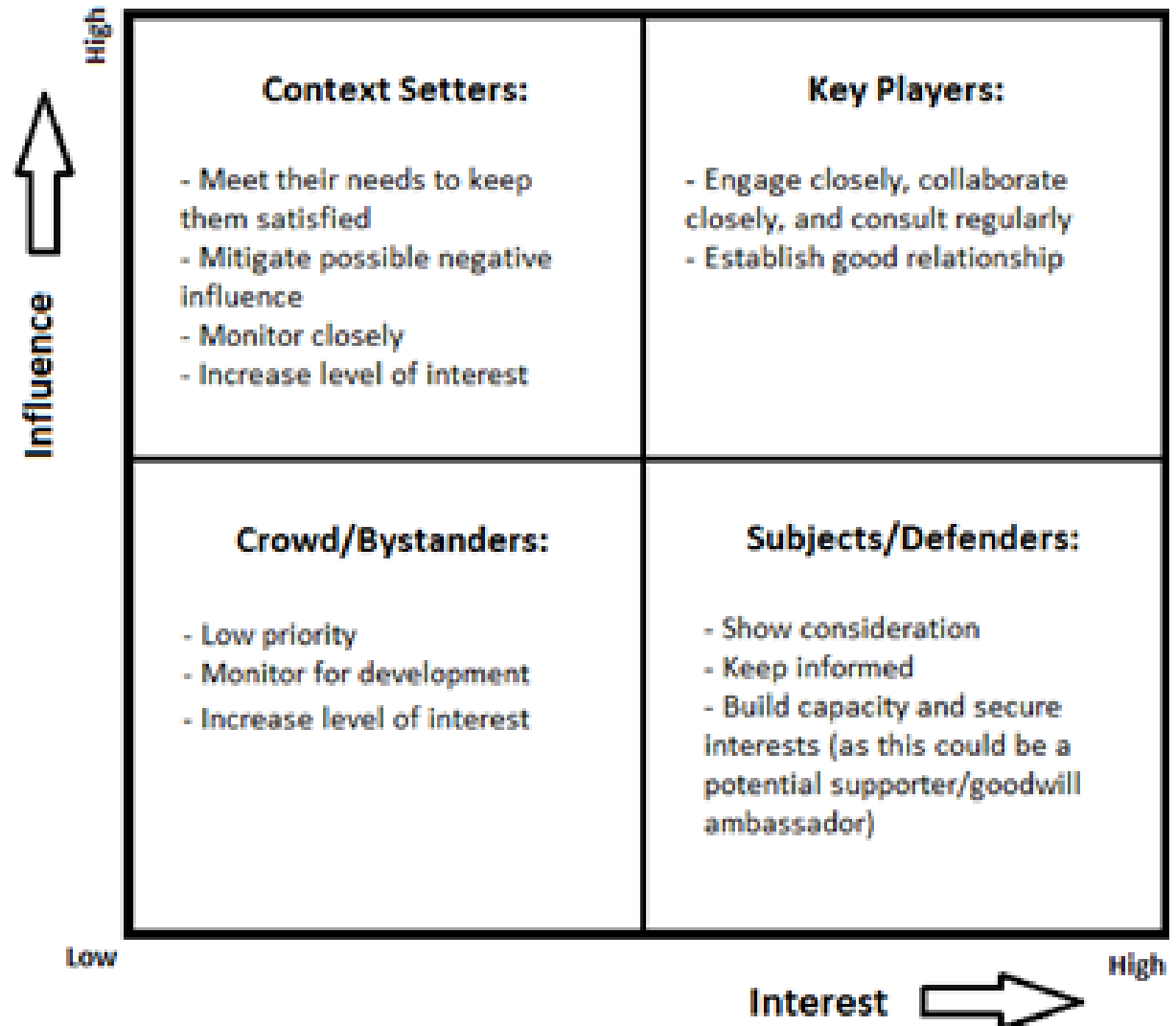


# Material Flow Analysis



# Stakeholder involvement

- Stakeholder analysis
- Key players = a.o. local communities
- Locals events: discuss Social License to Operate (SLO). Two-way communication starts with listening...
- High-level multi-stakeholder transition arena





# The Crocodile project benefits



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- ❑ Reduce drastically the supply risk of cobalt for the European industry
- ❑ Lower energy costs and environmental impacts
- ❑ Providing solutions with low capital investment costs
- ❑ Maximize the exploitation of the local waste.

# Contact

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