Respect

FOR A COMPETITIVE, CIRCULAR AND SUSTAINABLE EUROPEAN BATTERY MANUFACTURING INDUSTRY.

Hydrometallurgical Recycling of LIBs: the RESPECT project apporach

Cluster Hub – Annual Meeting

20th November 2025, Brussels and online

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RESPECT project overview

European Climate, Infrastructure and Environment Executive Agency
Project number: 101069865

COORDINATOR

Orano Mining

Justo Garcia

Coordinator

DURATION

2022 2023 2024 2025 2026

July 2022- June 2026

48 months

TOPIC

Recycling

Sustainable, safe and efficient recycling processes ID:

HORIZON-CL5-2021-D2-01-06

Type of action:

RIA

BENEFICIARIES

from 9 countries

15 organisations

+ 3 associated partners

BUDGET

8 906 936 €

from Horizon Europe

+ Associate partner funding:

1 000 000 CHF SERI

790 000 € UKRI

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Respect PARTNERS

FOR A COMPETITIVE, CIRCULAR AND SUSTAINABLE EUROPEAN BATTERY MANUFACTURING INDUSTRY.

FRANCE

orano

COUP'INDUS

cea

ceva LOGISTICS

UNITED KINGDOM

Addible

WMG THE UNIVERSITY OF WARWICK

BELGIUM

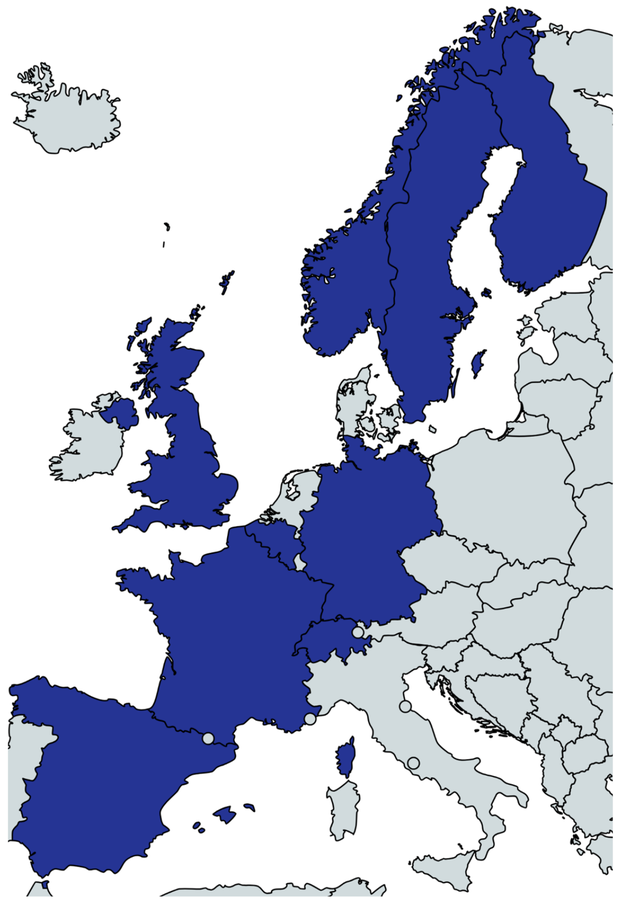
CLERENS

CLEPA European Association of Automotive Suppliers

SPAIN

LOMARTOV [Applied Innovation Engineering]

cidetec energy storage



NORWAY

MORROW Vianode

SWEDEN

CHALMERS UNIVERSITY OF TECHNOLOGY

FINLAND

Aalto University

Metso

GERMANY

Fraunhofer ISC

meet

SWITZERLAND

KYBURZ

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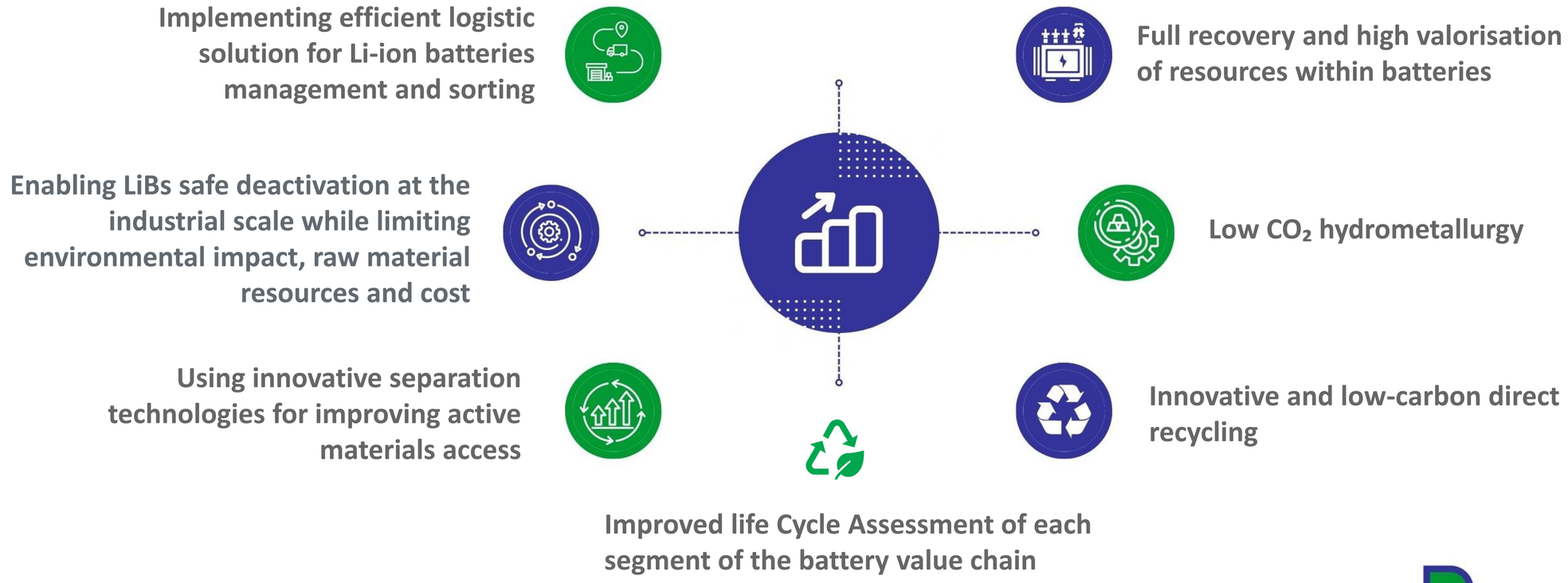
Tasks and Organisation

RESPECT's aim is to achieve efficient, sustainable, innovative and safe battery recycling processes in the EU encompassing new processes capable of achieving > 90% wt recovery rate/efficiency and supporting Li-ion battery manufacturing in Europe.

OUR OBJECTIVES



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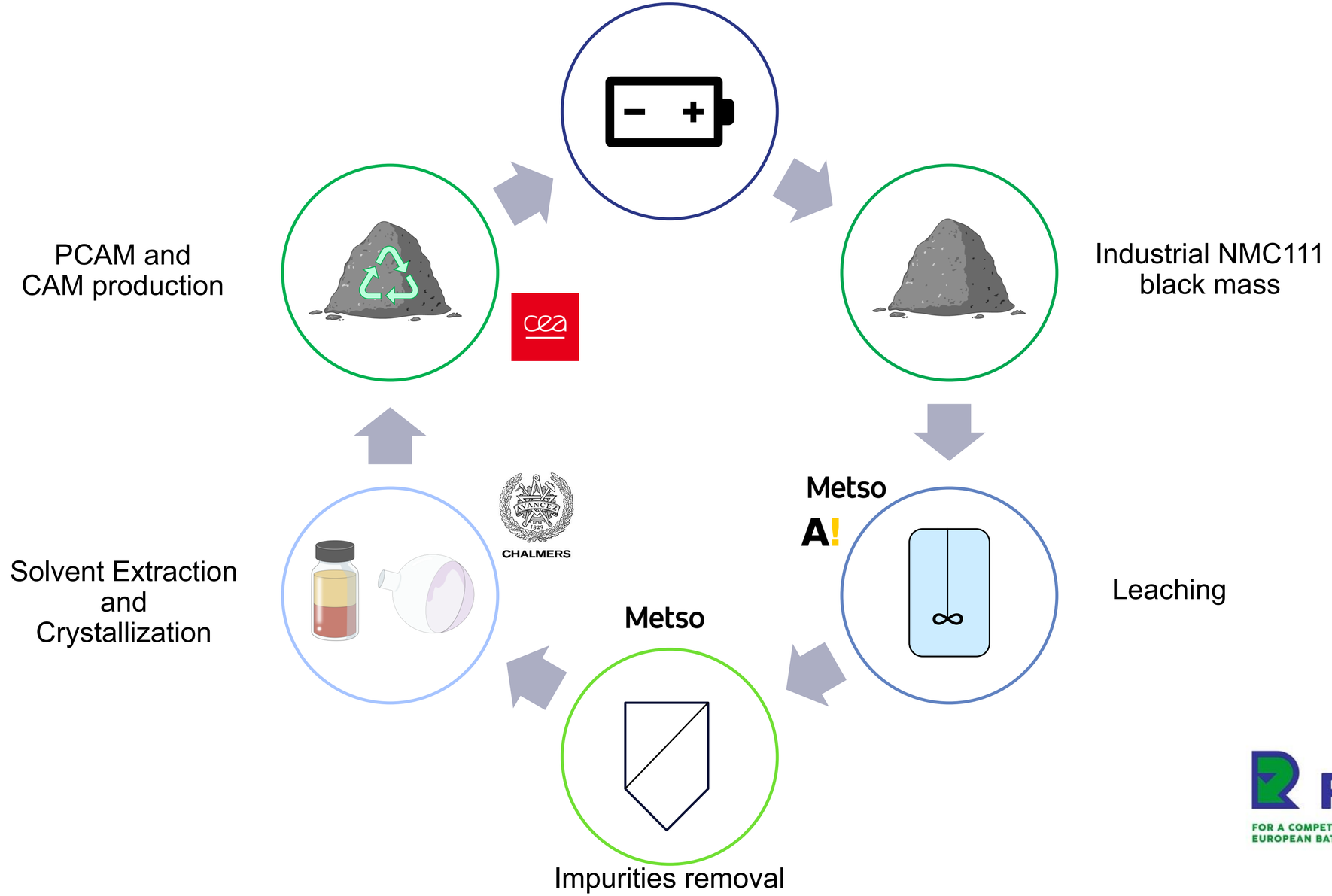
WP3: Innovative and low environmental impact hydrometallurgy



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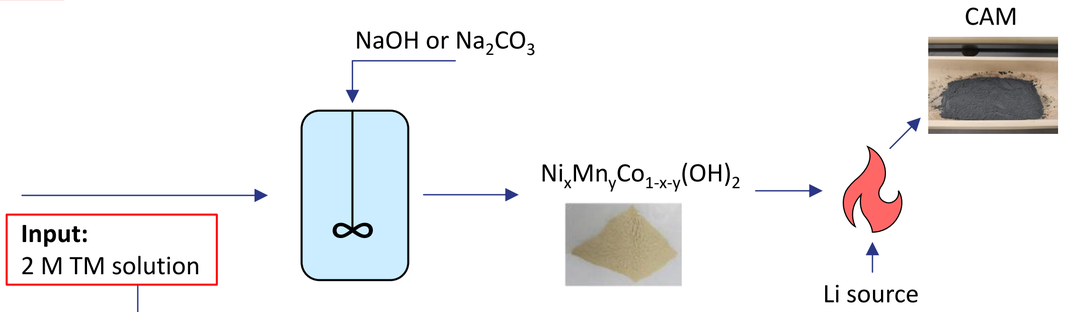
Strategies for NMC metals recovery

Aim: Recovery of Mn, Co and Ni in a form suitable to be used as precursors of CAM

PCAM precursor synthesis by co-precipitation



NMC	[Ni] M	[Mn] M	[Co] M
111	0.67	0.67	0.67
532	1	0.6	0.4
622	1.2	0.4	0.4
811	1.6	0.2	0.2
9.5.5	1.8	0.1	0.1
9.5-.25-.25	1.9	0.05	0.05

How can we obtain it from EoL LIBs?

Ni, Mn, Co recovery

Solvent Extraction	Precipitation	Ion Exchange
Mn, Co, Ni pure products	Mn, Co and Ni mixed product	Combination of mixed and pure products
+ Good product flexibility - Complex process	- Low product flexibility + Easier process	
Solid products Ex. salts	Liquid products	Combination of liquid and solid products
+ Easier transport + Easier NMC ratio adjustment in pCAM - Increases number of process operations	- Harder to transport (V↑) - Solubility limits use of liquid products + Lower number of process operations	

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Transition metals SX and crystallization

Feed composition after leaching and impurities removal

	Mn	Co	Ni	Li
g/L	12,73	14.62	10.79	4.91

Mn Solvent Extraction

	Mn	Co	Ni	Li
%E	99%	4%	5%	3%

Extraction

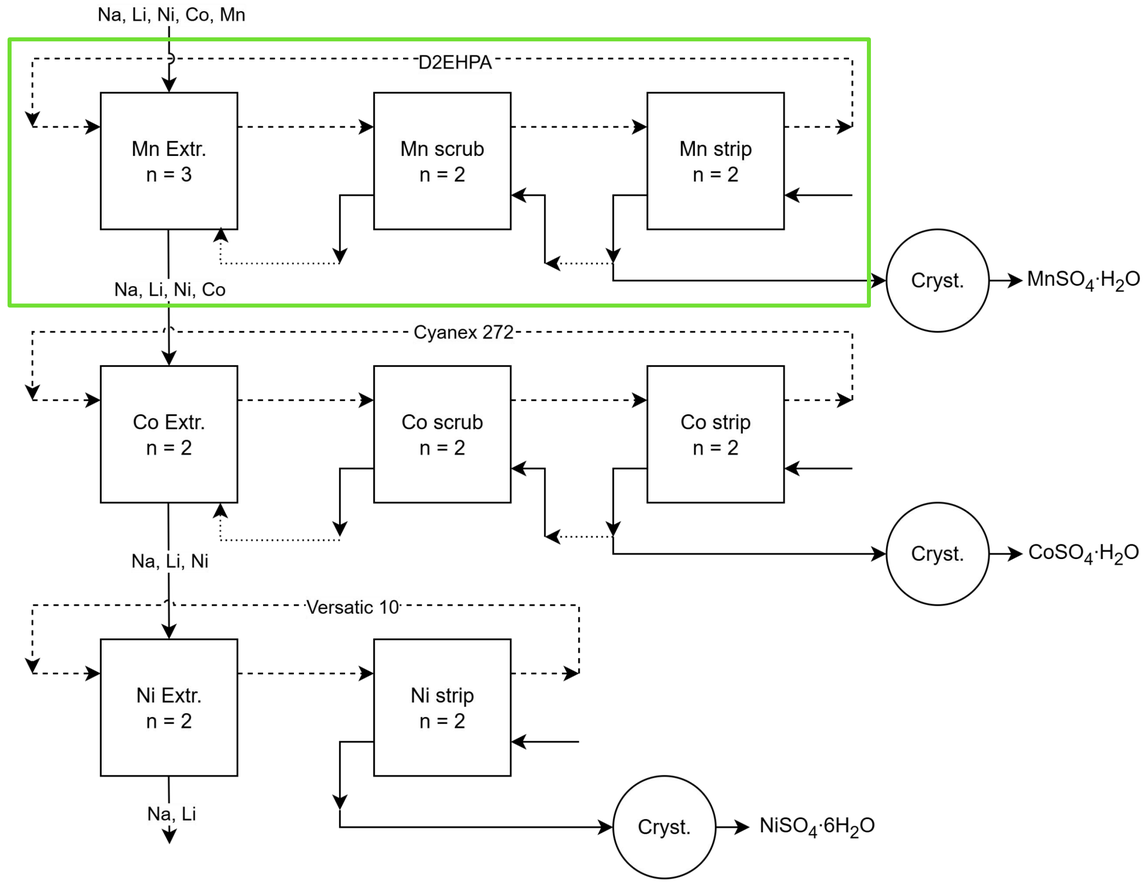
pH	3.0
θ	1
[D2EHPA]	1.05
Diluent	Isopar L

Scrubbing

[Mn]	4 g/L

Stripping

$[H_2SO_4]$	0.5 M



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Transition metals SX and crystallization

Feed composition after leaching and impurities removal

	Mn	Co	Ni	Li
g/L	12,73	14.62	10.79	4.91

Co Solvent Extraction

	Mn	Co	Ni	Li
%E	/	>99%	2%	1%

Extraction

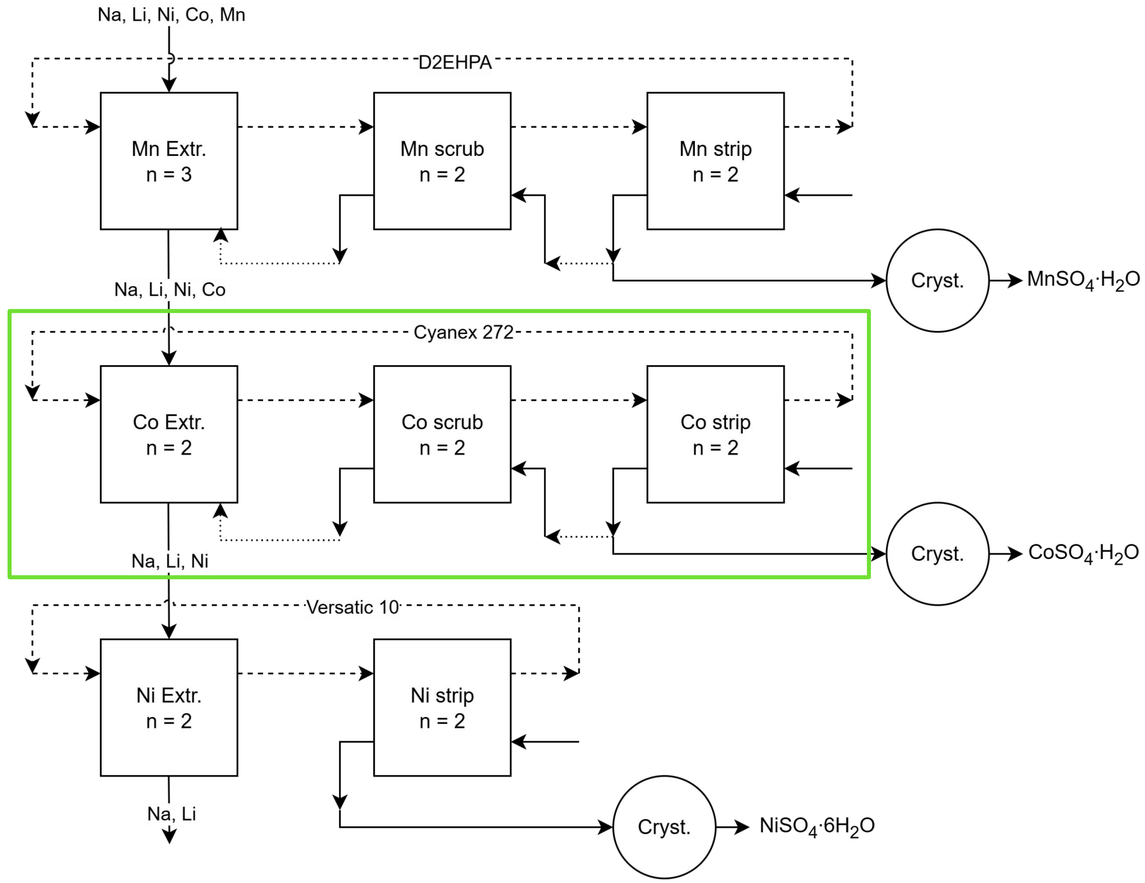
pH	5.7
θ	1
[Cyanex 272]	0.8 M
Diluent	Isopar L

Scrubbing

[Co]	1 g/L

Stripping

$[H_2SO_4]$	0.2



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Transition metals SX and crystallization

Feed composition after leaching and impurities removal

	Mn	Co	Ni	Li
g/L	12,73	14.62	10.79	4.91

Ni Solvent Extraction

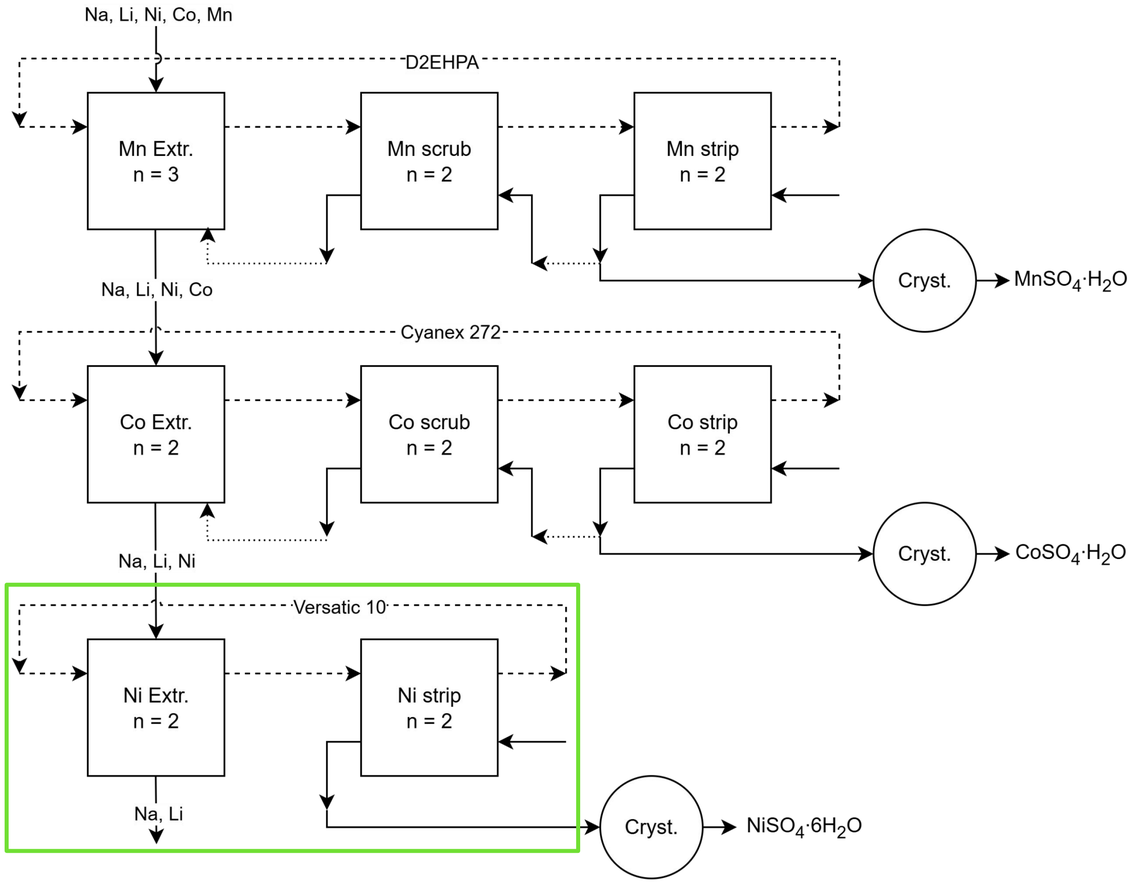
	Mn	Co	Ni	Li
%E	/	/	>99%	<1%

Extraction

pH	6.9
θ	1
[Versatic 10]	0.9
Diluent	Isopar L

Stripping

$[H_2SO_4]$	0.2



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Mn, Co and Ni products

$MnSO_4 \cdot H_2O$ composition and relative purity

Mn	Co	Ni	Li	Na	Zn	Mg	Ca	Cu	$P_{R,M}$
%w/w	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%
>32	2.5	<1	<1	1.5	1	<1	6	<1	**99.6**

$m_{tot} \approx 90$ g

$CoSO_4 \cdot H_2O$ composition and relative purity

Mn	**Co**	Ni	Li	Na	Zn	Mg	Ca	Cu	$P_{R,M}$
ppm	%w/w	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%
160	>34	600	/	30	8	1	/	2	**99.7**

$m_{tot} \approx 125$ g

$NiSO_4 \cdot 6H_2O$ composition and relative purity

Mn	Co	**Ni**	Li	Na	Zn	Mg	Ca	Cu	$P_{R,M}$
ppm	ppm	%w/w	ppm	ppm	ppm	ppm	ppm	ppm	%
/	1000	>22	/	/	/	/	/	/	**99.5**

$m_{tot} \approx 200$ g

Mn, Co and Ni sulphate salts products

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Performance of CAM produced from recycled transition metals product

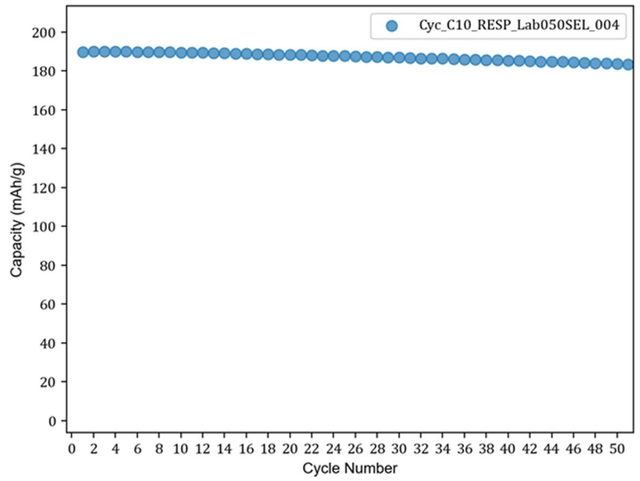
100 g NMC811 recycled synthesis done:

- **35 wt%** recycled dried salts from **CHALMERS**
- **65 wt%** commercially available precursors
- Commercial Li source

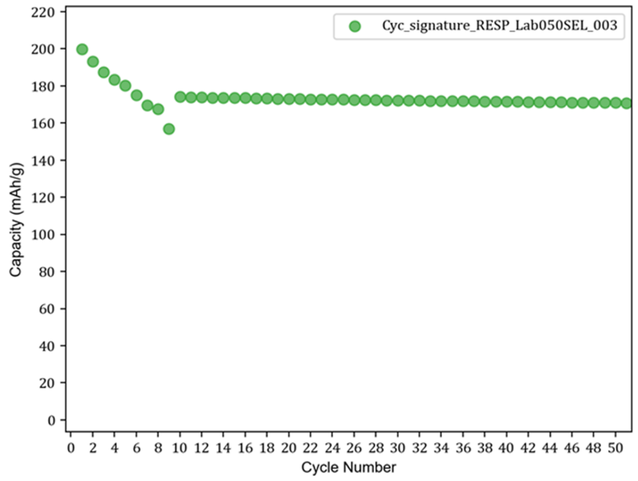
Close to 20% recycled material in Electrode

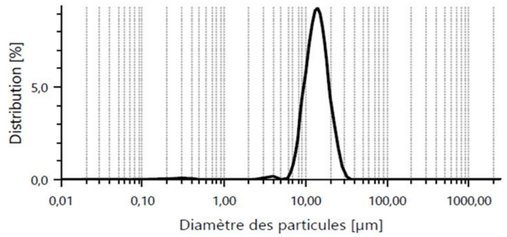
Tap density = 2.3 g/cm^3
D10 = 8.612 µm
D50 = 13.054 µm
D90 = 19.412 µm
SPAN = 0.827
No impurity seen in XRD

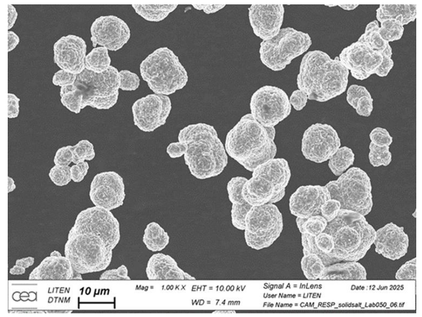
C/10 cycling HCC

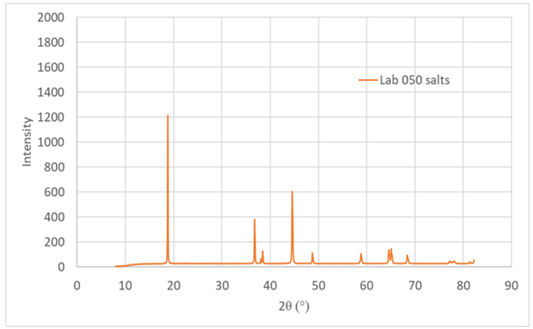


C-rate cycling HCC









✓ **Analysis results similar to reference obtained with commercial precursors**

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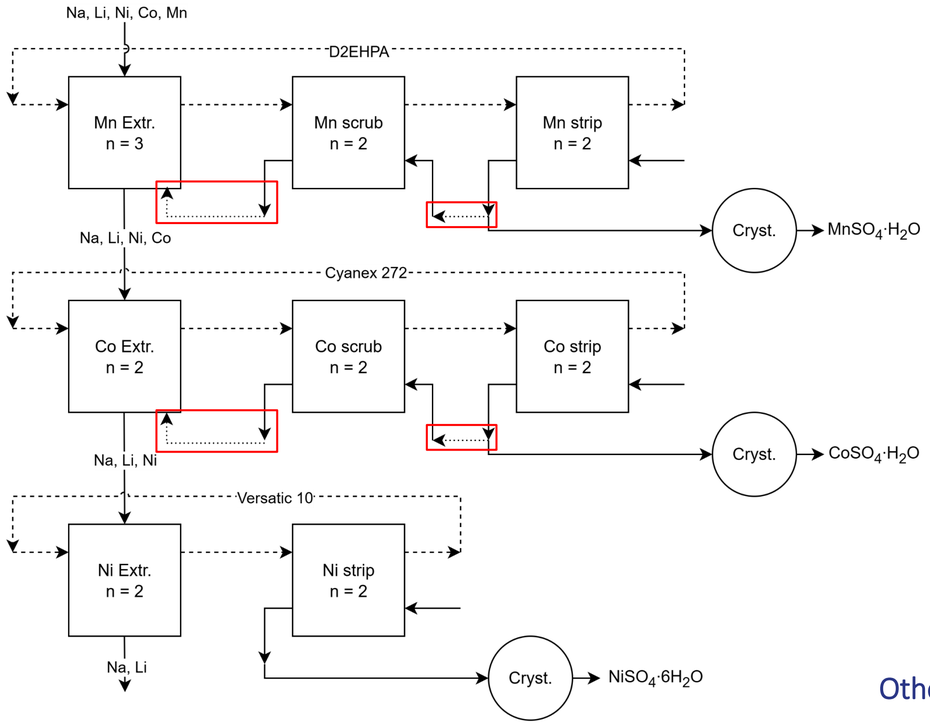
Advantages and Challenges of the investigated approach



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- Recovery of pure metals salts
  - High product flexibility (no bond to a specific NMC chemistry)
  - Easier transport to pCAM production facility

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- Many extraction, scrubbing and stripping operations involved
- Recirculation fundamental to avoid losses of valuable metals

Other considerations

- Adjustments of process paramteters needed to face changes in feed composition.
  (valid for SX but also for upstream oprations)
- Tolerance on Mn, Co and Ni contamination in the respective products depends on tolernace on NMC ratio in final product. (unclear information in the available documentation).

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Conclusions and Future developments

Conclusions

- A flowsheet for recovery of Mn, Co and Ni in sulfate salt was proposed.
- The CAM synthesised from the recycled salts showed promising results at lab scale (less than 1 kg).

Future work

- Further improvement and adaptation of the flowsheet are envisioned.
  - Investigation of streams recirculation.
  - Investigation of process flexibility as a function of the input material.
- Different strategies can be investigated to ease the number of operations in the process.
- Synthesis with higher quantity of recycled material should be performed.

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THANK YOU!

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