Recycling & Manufacturing of cathode active materials by Orano Batteries, towards a strategic independence of Europe

Justo GARCIA

Maison CentraleSupélec, Paris 8ème
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Orano

BATTERIES

01 Orano group

Orano ensures excellence right across ...

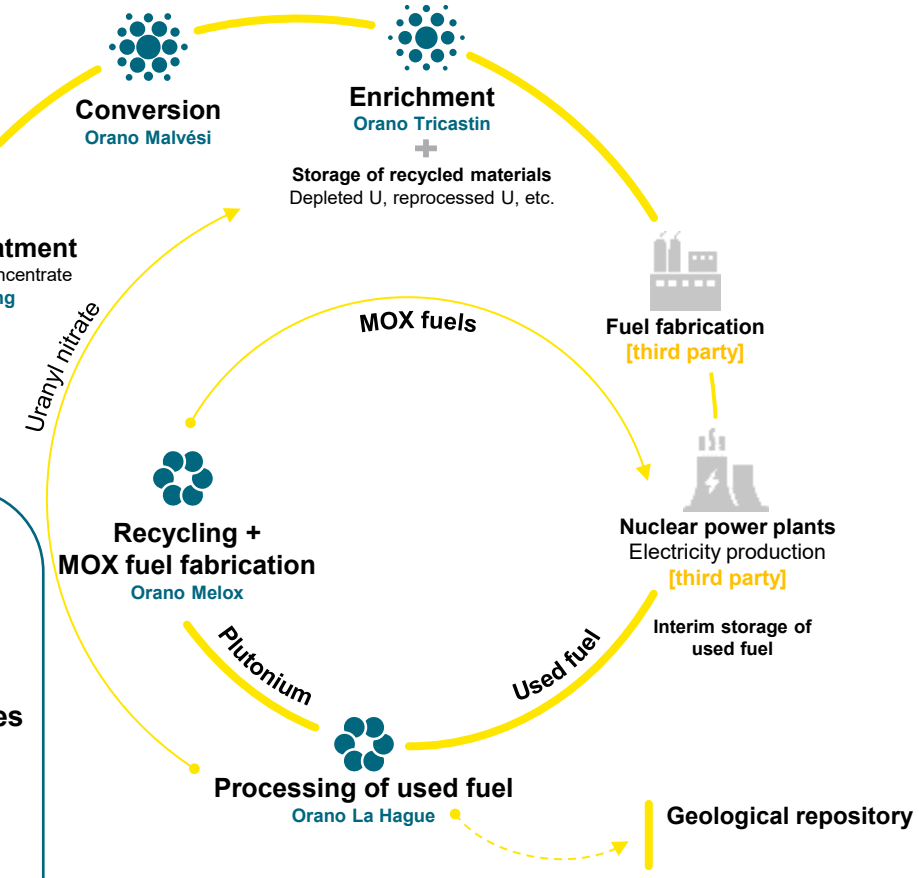
... the nuclear fuel cycle ...

2024

5,9 B€
of revenues

35,9 B€
Order backlog

18 000
employees



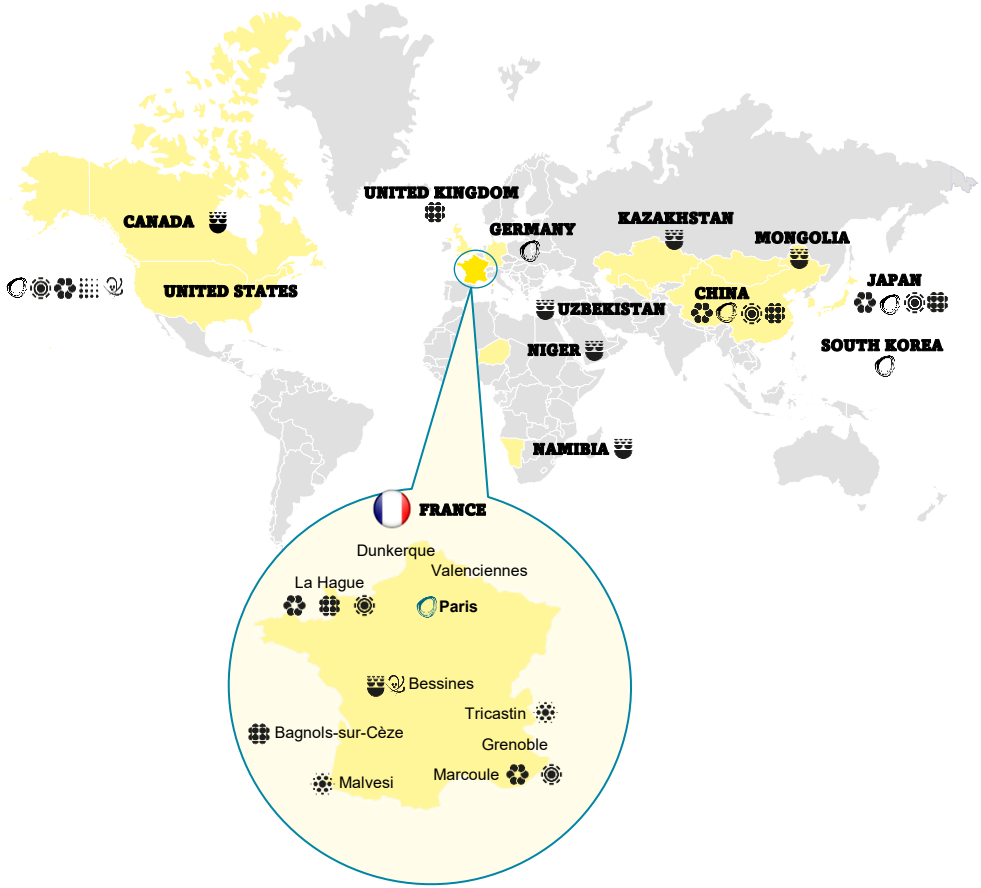
Nuclear services

- Engineering
- Transportation & Services
- Decomm. & Services

New activities

- Orano Medical
- Orano Batteries
- Production of stable isotopes

... with an international footprint



> Develop know-how in the transformation and control of nuclear materials for the climate, for a healthy and resource-efficient world, now and tomorrow

ELECTRIC VEHICLE BATTERIES

Orano commits to responsible transport solutions

In collaboration with French and international partners, Orano has developed a process to recover and purify the valuable materials contained in end-of-life electric vehicle battery modules and scrap from gigafactories (cobalt, manganese, nickel, lithium, graphite), so that they can be reused in new components.

An industrial platform project is expected to start from 2027 **in Dunkirk (Hauts-de-France) with the construction of a recycling plant and two factories manufacturing cathode active materials (CAM) and their precursors (P-CAM). This project will complement the battery value chain and meet the objective set by the European Union to gradually introduce recycled materials into new electric vehicle batteries.**

THE CHALLENGES

- ✓ **Become a key player in the recycling** of Lithium-ion (Li-ion) **electric vehicle batteries** and **the production of P-CAM/CAM** in France and on the European market.

The Neomat project involving two joint ventures with XTC New Energy to manufacture CAM and P-CAM.

An innovative, low-carbon hydrometallurgical process to recover materials of interest.

2 industrial pilots of pre-treatment and hydrometallurgy at Orano Bessines-sur-Gartempe.

1,300
direct jobs expected in Dunkirk

3
Projects of factories in Dunkirk from 2027

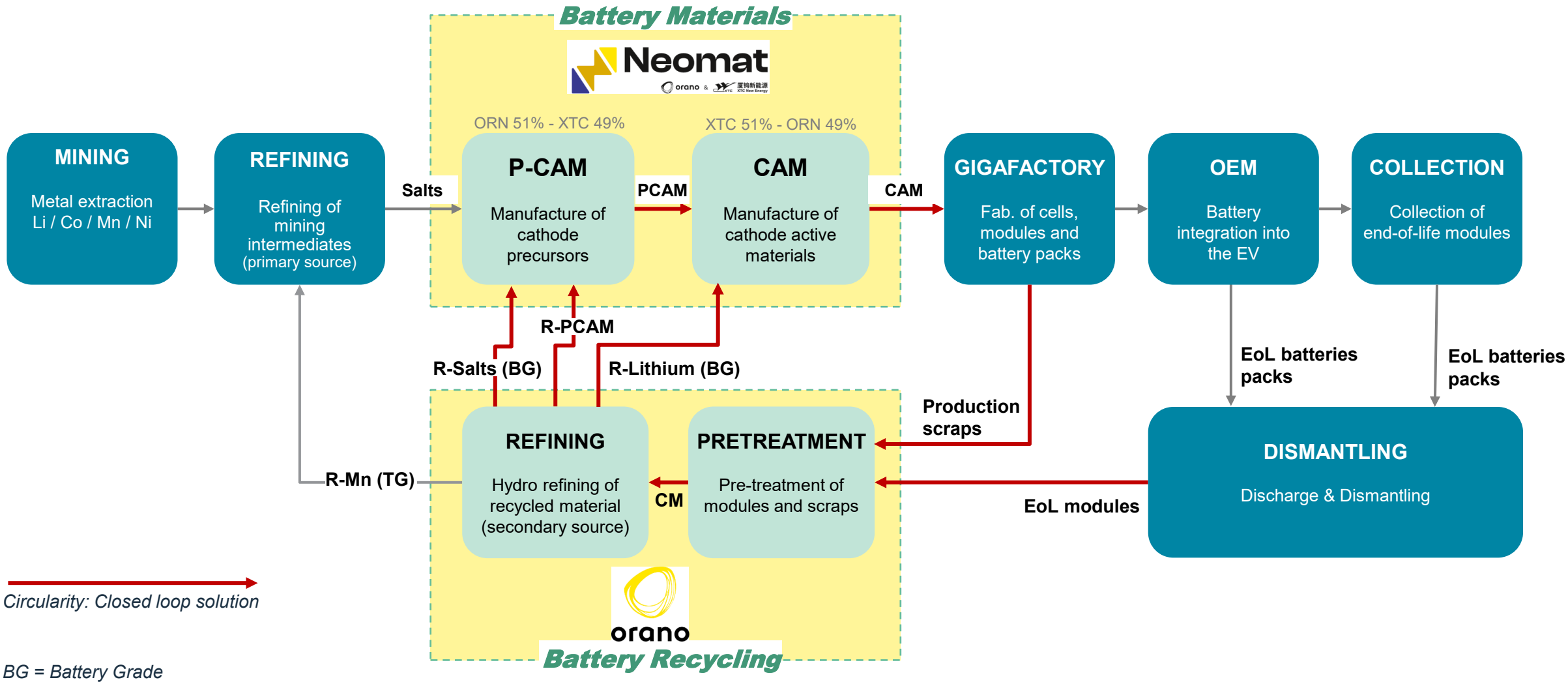
80,000 T
of CAM produced per year, allowing the manufacture of 64 GWh of batteries, equivalent to 1 million of EVs

20,000 T
of black mass recycled per year*

*Full capacity target

2023 figures

Orano & Li-Battery Value Chain I Orano battery project addresses CAM / PCAM production and Recycling on the lithium battery value chain

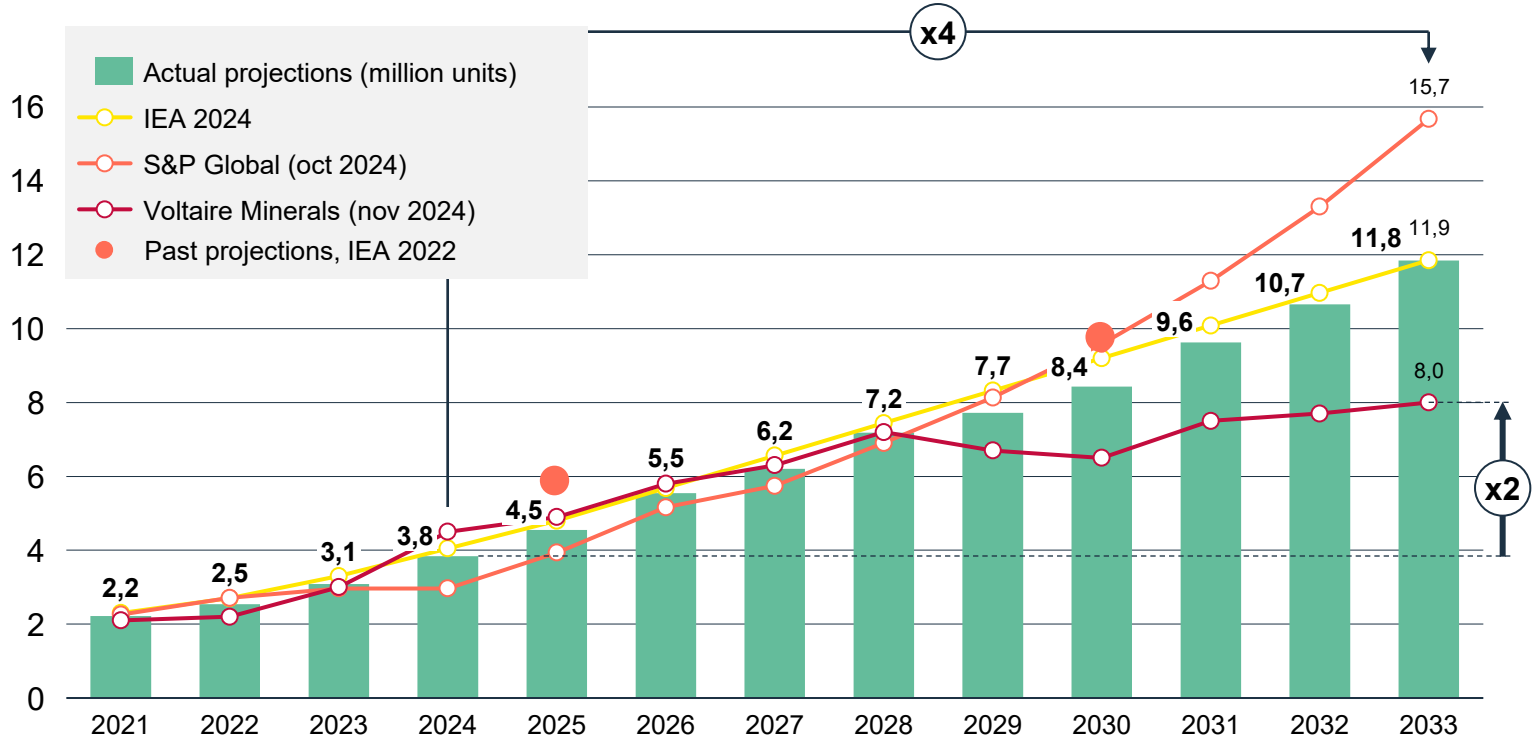


BG = Battery Grade
TG = Technical Grade
CM = Cathode Mix or Black Mass

02 European EV market and drivers

EV market I The EV market will continue to grow with sales doubling or even quadrupling by 2034 in the most optimistic case

Projected sales of electric vehicles (BEVs & PHEVs) in Europe (million EVs)



- The rationale for the next few years remains the same
- EV growth remains robust, with an estimated ~12 million EV sold in 2033 in Europe

EV sales growth over 2024-2033:

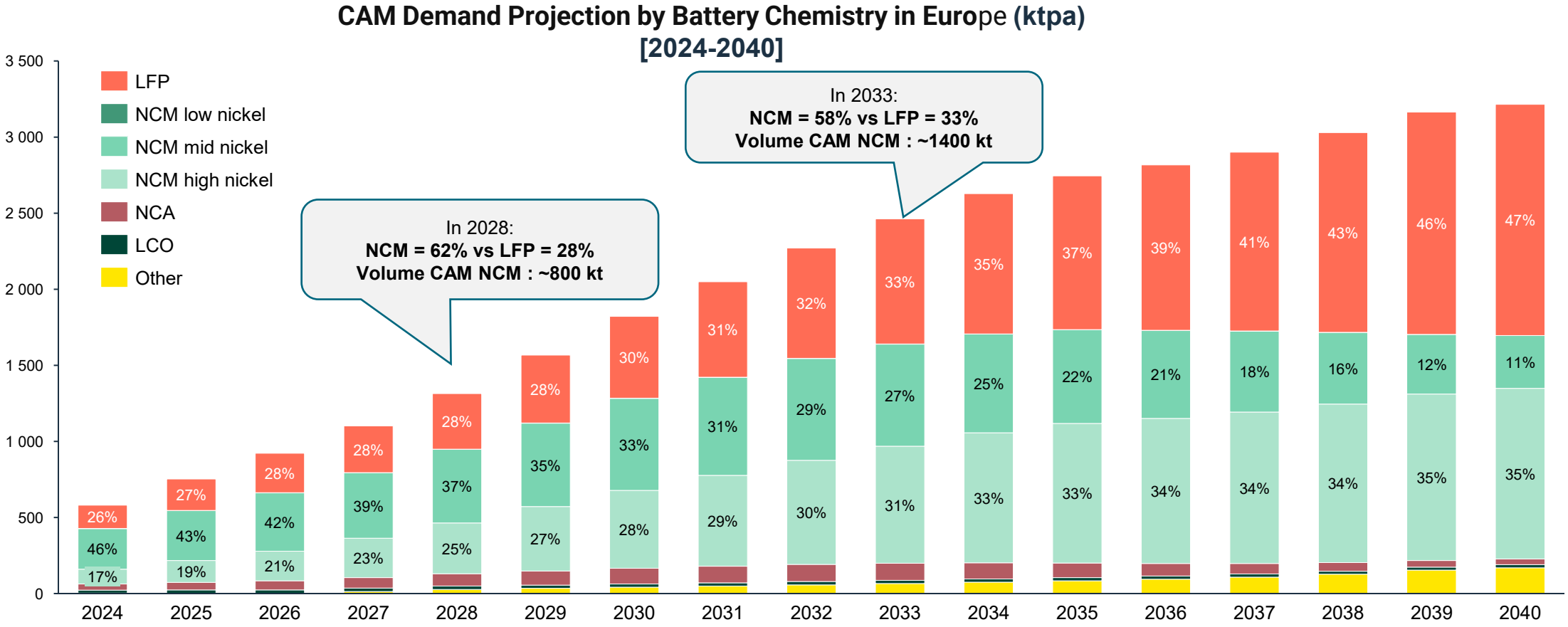
- Voltaire Minerals: **x2**
- Scenario IEA 2024: **x3**
- Scenario S&P Global: **x4**

- Compliance with the Paris Agreement:
  - Carbon neutrality by 2050 ➔ « *100% zero-emission car target* » in the EU by 2035
  - Obligation to decarbonise the automobile sector because the transport sector is one of the most CO_2 emitters (12% of the EU's CO_2 emissions)
- All OEMs have started their transition to electric and have invested heavily in (i) the development of new industrial tools and (ii) a resilient supply chain for EV production

➔ **No backsliding to the combustion vehicle and this guarantees a robust outlook for EVs in Europe**

Sources : IEA 2024 (scenario STEPS), S&P Global, Voltaire Minerals

CAM market | Despite the growth of LFP chemistries, NCM chemistries will remain one of the majority chemistries in Europe



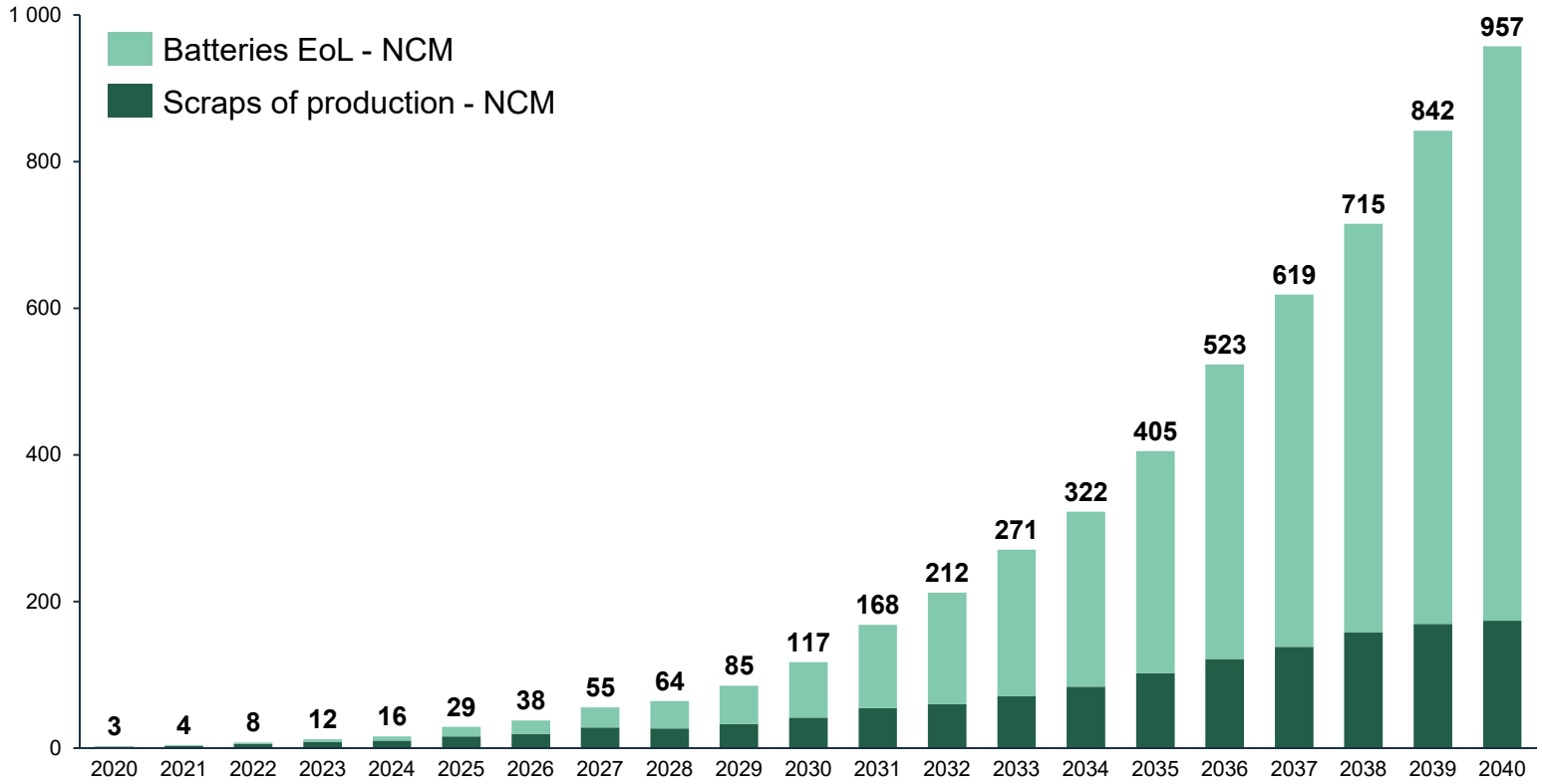
LFP, NCM mid nickel and NCM high nickel chemistries will remain the most representative chemistries until 2040 in Europe
In 2040: **NCM = 46%** vs **LFP = 47%**

Source: Benchmark Mineral Intelligence, Oct 2024.

Recycling market | Recycling market forecasts are delayed in time due to the delay in (i) EV sales forecasts and (ii) the deployment of *gigafactories*

Recycling market en Europe – NCM – (kt)

Batteries EoL NCM and scraps of production NCM



Initially, mainly scrap, then end-of-life batteries

Sources : Moyenne réalisée avec les données de BMI et de Voltaire Minerals.

Eu's answer to strengthen the battery industry

Important Projects of Common European Interest (IPCEI)

- State aid for highly innovative industry-driven projects at high funding intensities, long-term impact through RDI and first industrial deployment

Critical Raw Materials Act (CRMA)

- Regulation for domestic capacities and diversified supply chains for strategic raw materials

Net Zero Industry Act (NZIA)

- Simplification of regulatory framework and fast track permitting

Battery Regulation

- Regulatory framework for all environmental and social aspects of batteries
- Mandatory sustainability requirements
- Safety and labelling requirements

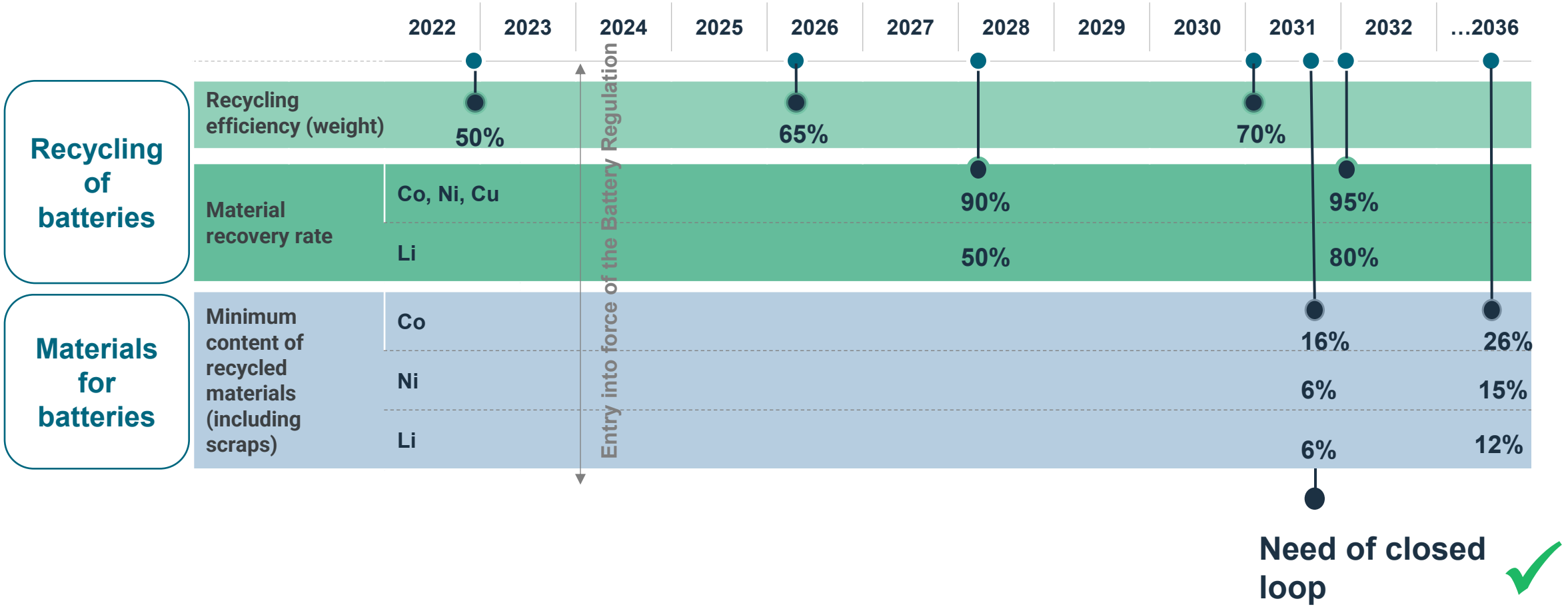
Temporary Crisis and Transition Framework (TCTF)

- Member State aid for the production of batteries, their key components or the recovery of raw materials.
- Possibility to match state aid offered in non-European locations.

Industrial Accelartor Act

- Facilitating industrial production and decarbonization
- Strengthening the EU's industrial value chains
- Controlling Foreign Direct Investment

Targets set by the Batteries 2023 Regulation* for material recovery, recycling efficiency and minimum recycled content in new batteries



** Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries*

EU regulation: Critical Raw Materials Act Priorities

- **No more than 65%** of the EU's supply of each SRMs should come **from a single third country** for reducing the EU's dependence on third countries and diversifying its supply

- **At least 10%** of the EU's **annual consumption** of strategic raw materials should **originate from EU extraction.**

- **At least 40%** of the EU's **annual consumption** of strategic raw materials should be **processed in the EU.**

- **At least 25%** of the EU's **annual consumption** of strategic raw materials should be **recycled.**

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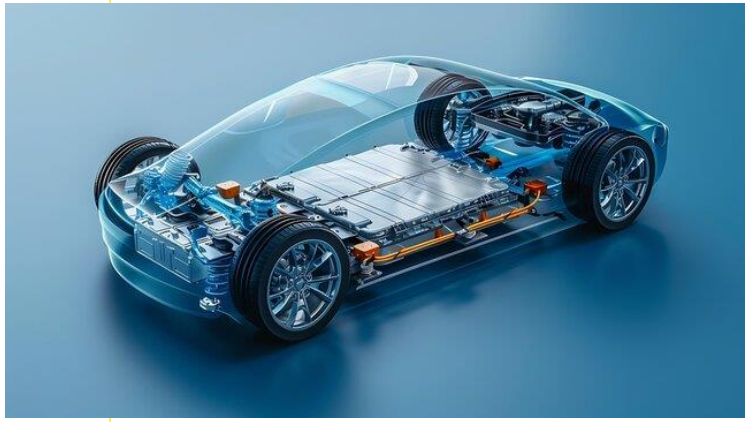
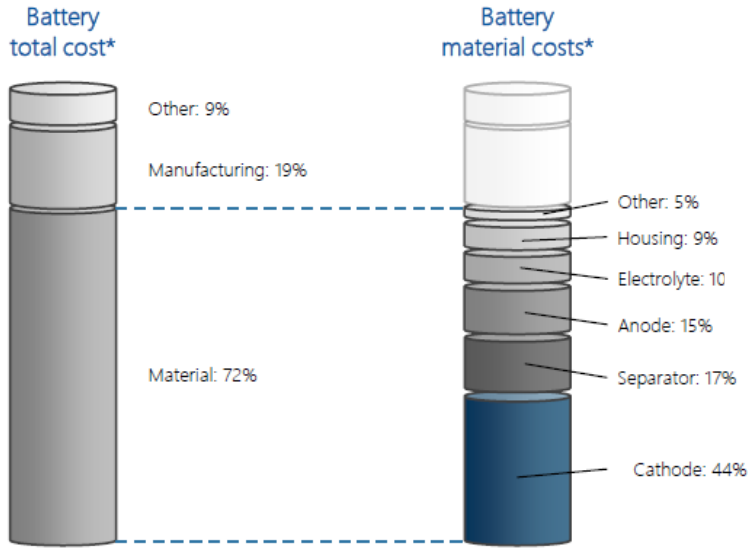
Pack, batteries, modules and cells…
What materials should be recycled in batteries?

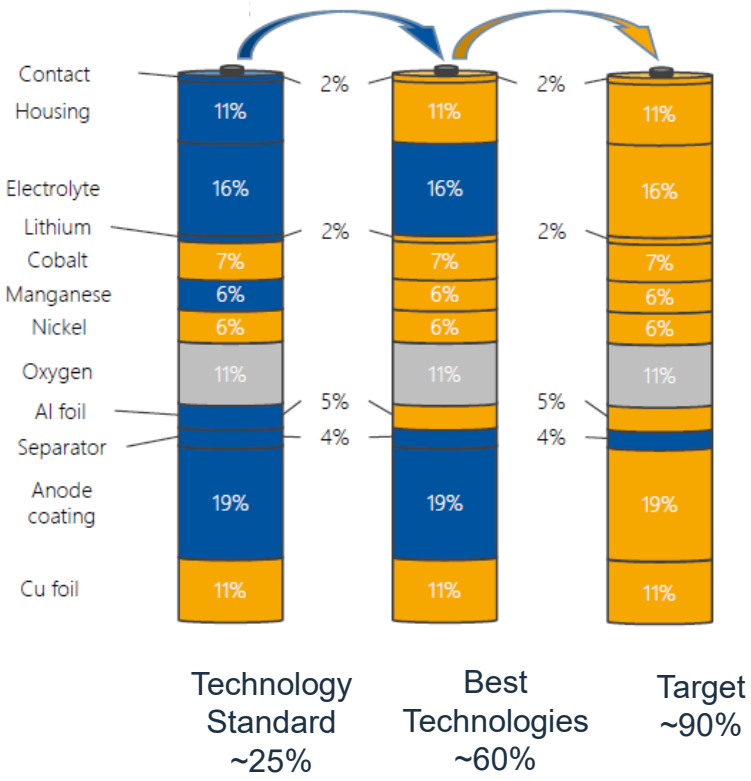


Cost overview

Fundamentals



Recycled materials in batteries (orange)



Why recycle Batteries ?

1. **Reduce CO2 emissions and energy consumption**

2. **Ethical supply chain**

3. **Secure raw materials and preserve natural resources**

   - **Supply chain stability**

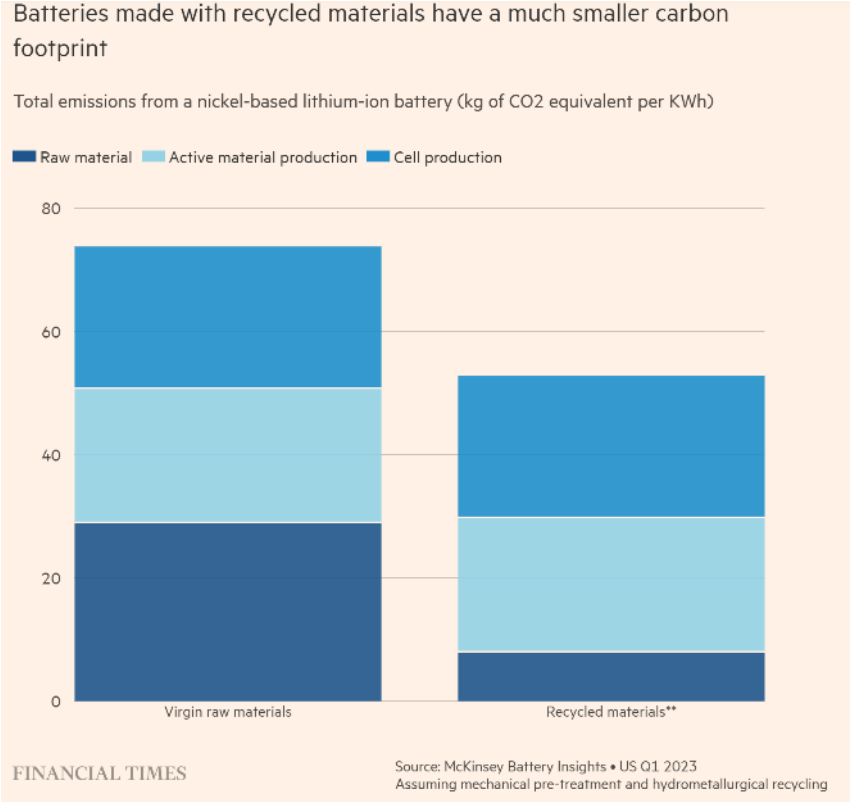
4. **Control cost and pricing**

   - **Reduce volatility of price**

5. **Regulatory drive**

   - **EU Battery Regulation, CRMA**

30% **smaller carbon footprint using recycled materials in battery**



03 Orano Batteries' innovative Processes

Orano Batteries' Program closes the loop in the Battery value chain with its Recycling and Synthesis of Cathode Active Material


EOL


Cathode Scrap


Cell/module scrap


Stack scrap


Black mass

Neomat

orano & XTC New Energy

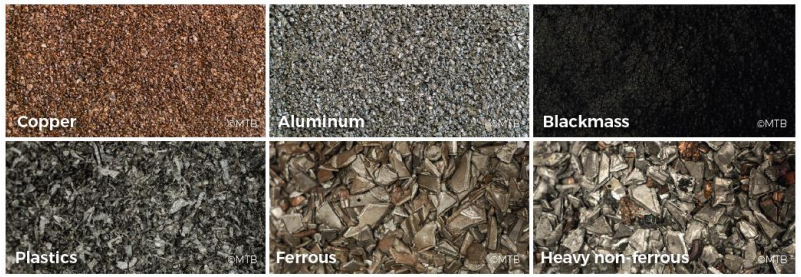
Pretreatment

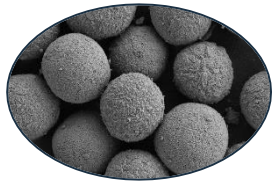

Black mass

Hydrometallurgy

pCAM

CAM





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The state of the art: the current recycling processes

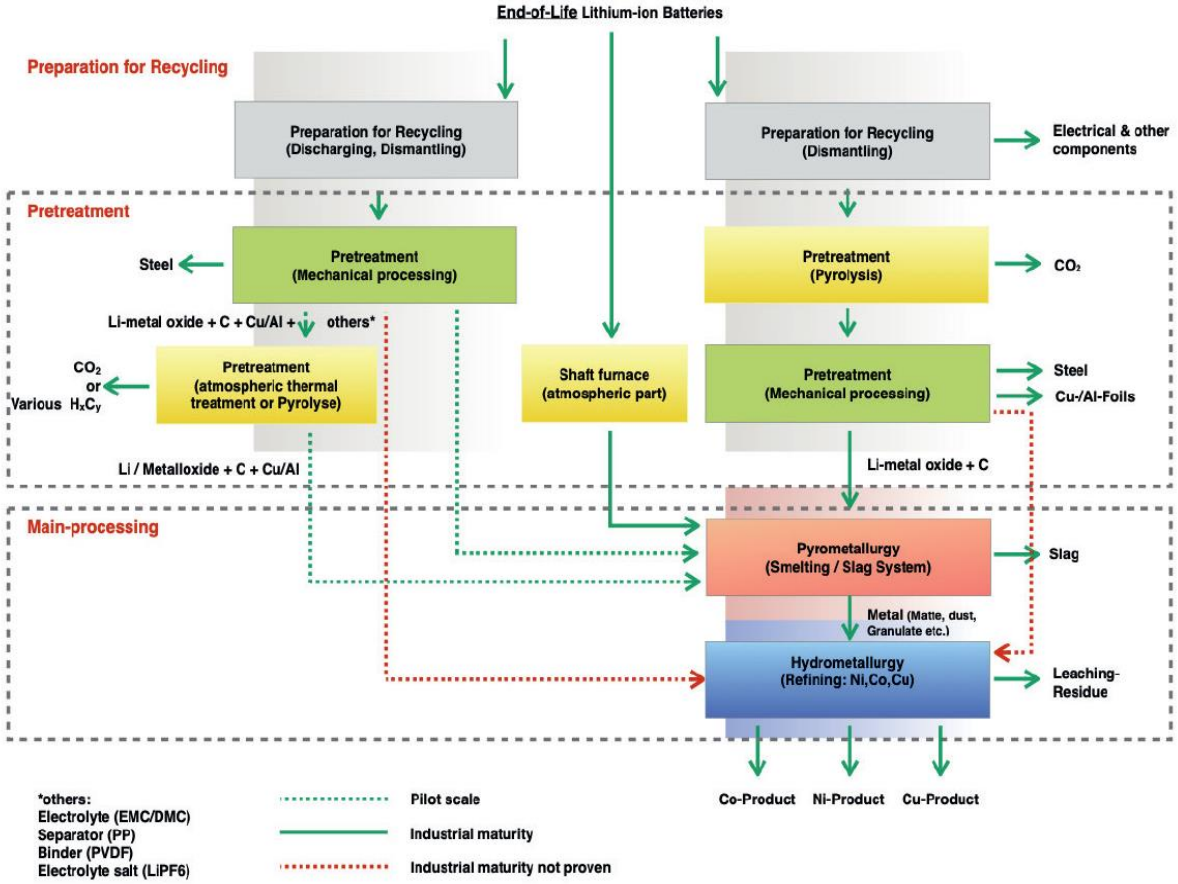


Figure 5: Overview about schematized Li-ion batteries recycling routes

Comparative study of Li-ion battery recycling processes
Reiner Sojka*, Qiaoyan Pan, Laura Billmann | ACCUREC Recycling GmbH | September 2020

Comparison of different LiB recycling methods Best ••••• •••• ••• •• • Worst

	Technology readiness	Complexity	Quality of recovered material	Quantity of recovered material	Waste generation	Energy usage	Capital cost	Production cost
Pyrometallurgy	•••••	•••••	•	•••	••	•	•	•••••
Hydrometallurgy	••••	•••	•••	••••	•••	•••	•••	•••
Direct recycling	••	•	••	•••••	••••	•••	•••	•

	Presorting of batteries required	Cathode morphology preserved	Material suitable for direct re-use	Cobalt recovered	Nickel recovered	Copper recovered	Manganese recovered	Aluminium recovered	Lithium recovered
Pyrometallurgy	•••••	No	No	•••••	•••••	•••••	••	No	•
Hydrometallurgy	••••	No	No	•••••	•••••	••••	•••	•••••	•••
Direct recycling	•	•••••	••••	•••••	•••••	•••••	•••••	•••••	•••••

Fig 29: Comparison of different Lithium-Ion batteries recycling (Nature: Recycling lithium-ion batteries from electric vehicles, November 2019).

Orano Battery Recycling I An innovative recycling process

Pre-treatment

To Hydrometallurgy

EoL modules

Activated components

Electrically discharged components

Scrap cells and modules

Manufacturing scrap

Electrode stack

Anode electrode

Cathode electrode

Cathode Mix purity > 90 %

Deactivation

- Components secured through a disruptive deactivation process
- Release of energy avoiding thermal runaway, gas generation, inflammability and/or explosion

Stack extraction

Casing (Al)

Electrode separation

Liquid (Electrolyte)

Graphite Separation

Sorting and sieving

Al Cu Plastics

Graphite-rich fraction

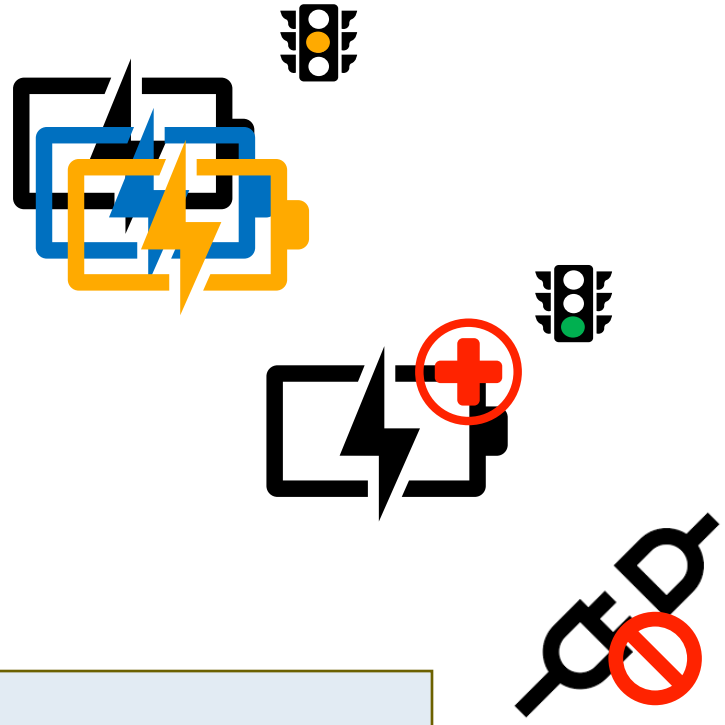
Anode scrap Graphite

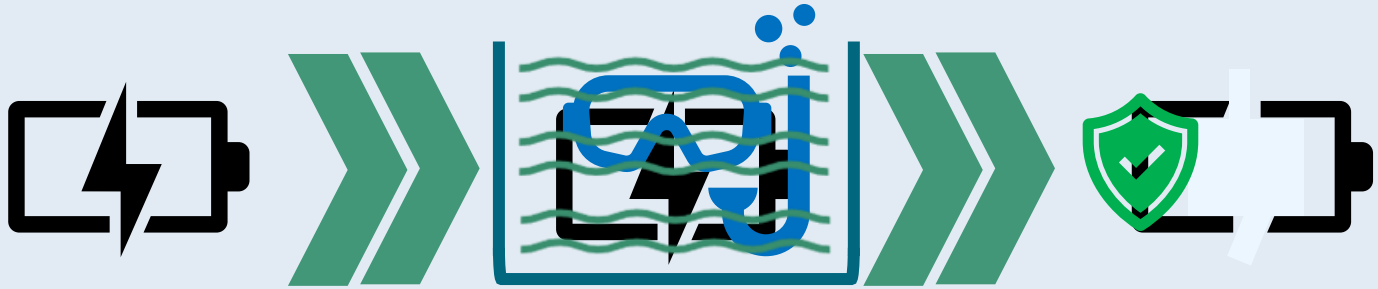
Orano disruptive technology: Deactivation process to ensure safe recycling process

- ✓ Breaking with current technologies
- ✓ Safe technology for facilities and people

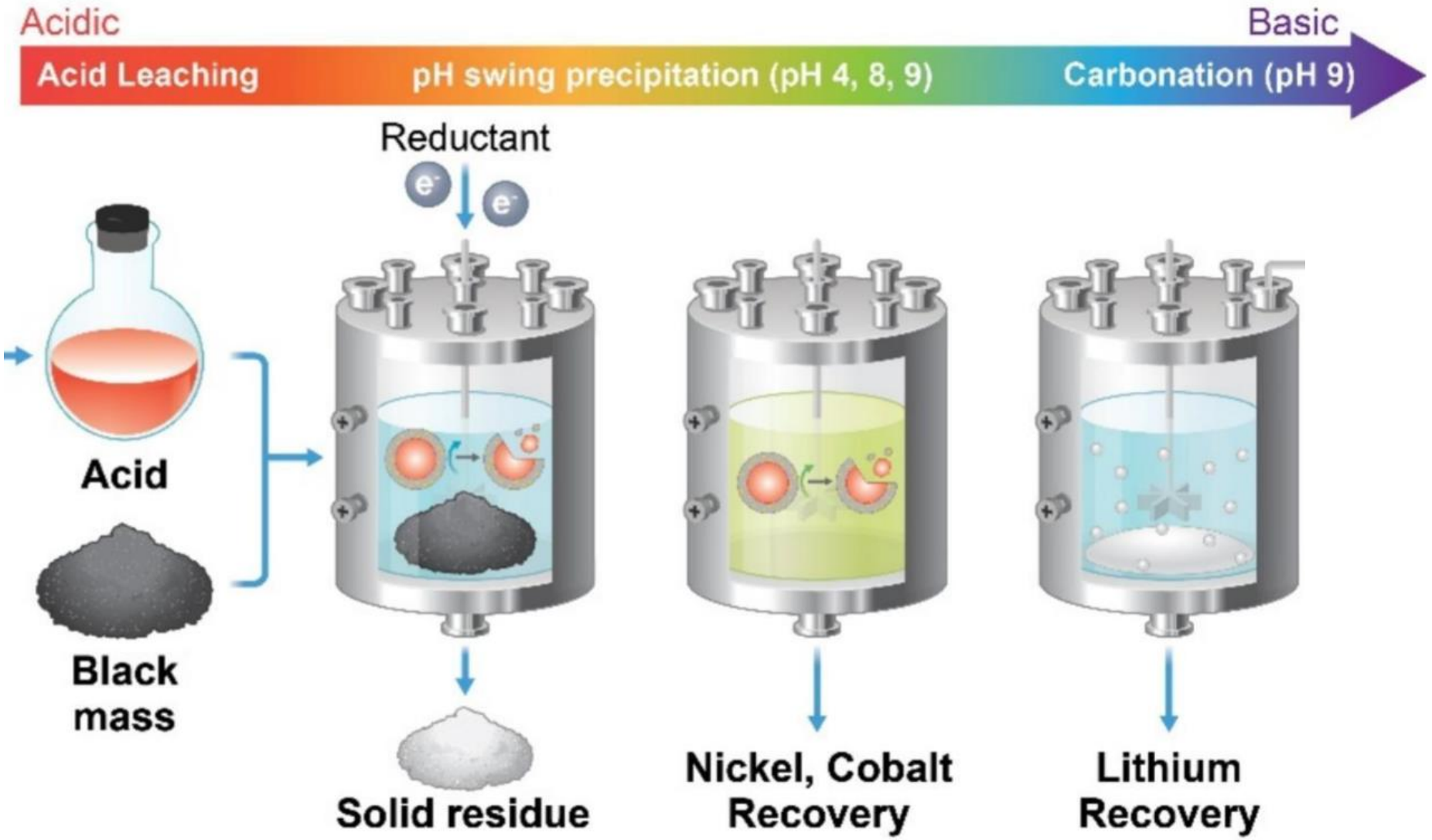
Orano Technology

- No major risk: Residual energy is released in a safe and controlled manner
- Applicable to all technologies and chemistries: inherently versatile technologies
- Low footprint: No reagent consumption, at room temperature, automatable without operator intervention and low carbon
- Efficient: No degradation of internal materials with reduced cycle times

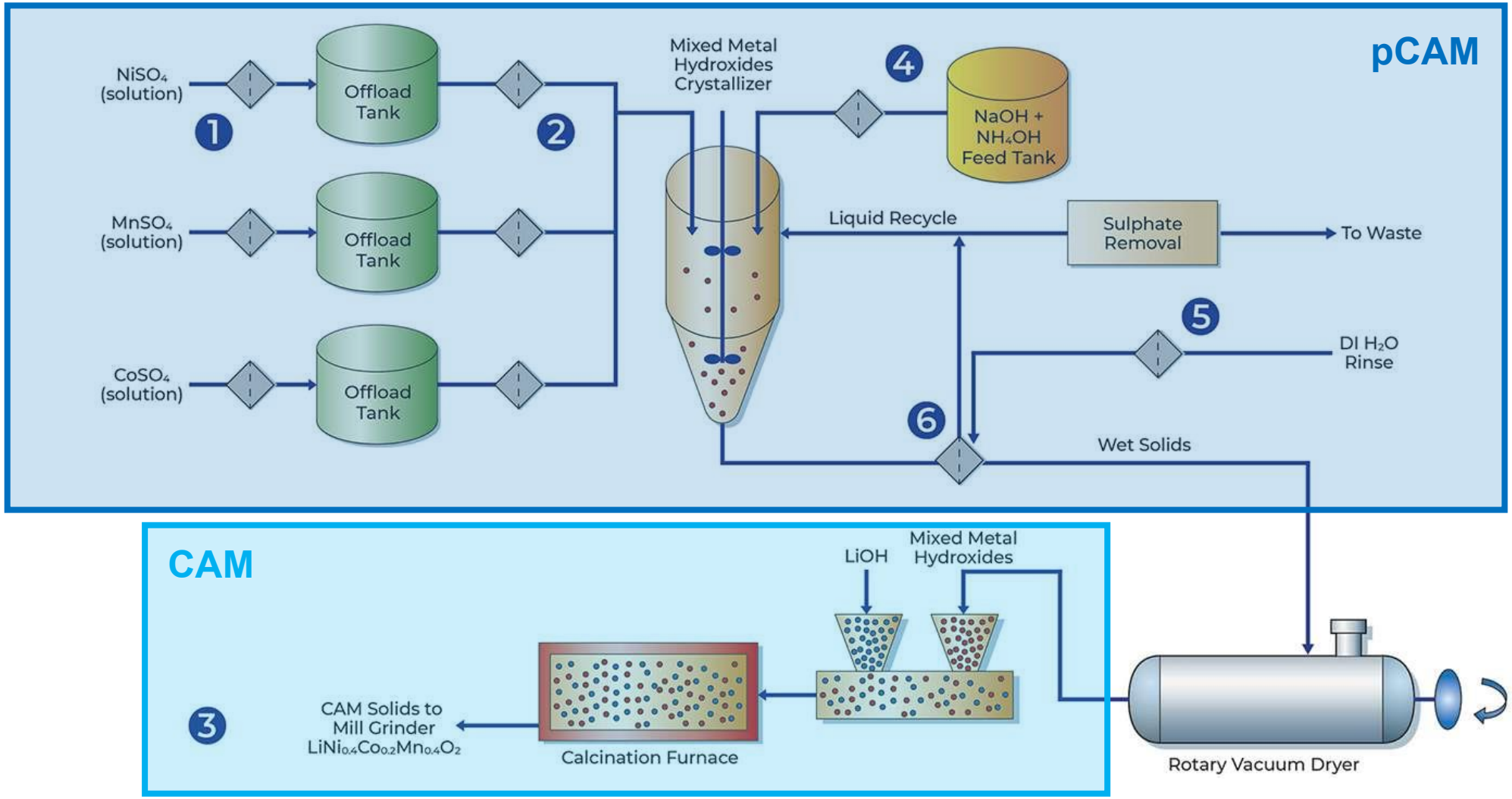




Orano Battery Recycling I Hydrometallurgical process: from black mass to metallic salts



Orano Battery Materials I Manufacturing of Cathode Active Materials (standard route)



Recycling & Cathode Material Manufacturing I Innovative processes by Orano Batteries

EoL modules

Pre-treatment

Activated components

Electrical discharged components

Deactivation

- Components secured trough a disruptive deactivation process
- Release of energy avoiding thermal runaway, gas generation, inflammability and/or explosion

Stack extraction

Casing (Al)

Electrode separation

Liquid (Electrolyte)

Graphite Separation

Graphite

Sorting and sieving

Cathode Mix purity > 90 %

Al

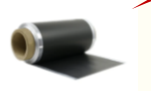
Plastics

Cu

Cells and modules

Electrode stack

Anode electrode



Cathode electrode

Manufacturing scrap

Hydrometallurgy

Leaching

Impurities precipitation

Cu, Al, Fe…

2 Resolution to PCAM

Purification

1 Resolution to SALTS

SX Mn

SX Co

SX Ni

Li_2SO_4 Na_2SO_4

Mn sulfate crystallization

Co sulfate crystallization

Ni Sulfate crystallization

Li crystallization

$MnSO_4.H_2O$

$CoSO_4.6H_2O$

$NiSO_4.7H_2O$

$LiOH.H_2O$

Purification of graphite

Regeneration to battery grade

PCAM/CAM

Stoechiometric adjusment

Li_2SO_4 Na_2SO_4

PCAM synthesis via coprecipitation

CAM plant

04 Our industrial project in Dunkirk (France)

The 4 pillars of industrialization

Technique

- Scaling up
- Robustness of the process
- Real performance

Safety and regulations

- Personal Safety
- Environment
- Authorisation (ICPE, Seveso, etc.)

Industrialization

Human

- Organization
- Education
- Coordinate the commissioning

Industrial and economic

- Equipment reliability
- Maintenance
- Costs & Deadline

"Industrialization is the set of technical, human, regulatory and industrial steps that make it possible to design, build, start up and operate a production facility in a sustainable manner."

From the laboratory to the factory: scaling up

Laboratory
R&D
Proof of concept

Pilot
Process adjustment
Definition of technologies
Operating conditions
Robustness of the process

Engineering
Preliminary & detailed designs (APS/APD)
Regulatory
Realization
Safety

Commissioning
Reception (SAT&FAT, ...)
Training
Ramp-up

Orano Battery Program I A selected site for the project in Dunkirk in North of France

	Capacity	Investment M€	Jobs en 2035
Neomat PCAM/CAM	**38 kt** CAM plant starting from 2028 (expandable to 80 kt) 25 kt PCAM plant starting from 2031 (expandable to 50 kt)	~ 1500 M€	1200
Recycling	**15 kt** BM hydro refining capacity in 2030 (expandable to 30 kt) BM		100

☞ **Total investment: up to 1.5 B Euros ; total direct employees: up to 1300 jobs in 2030**

05 Where is Orano's Battery Program standing today ?

Where is Orano's Battery Program standing today ?

Orano's battery recycling project designated "strategic" by the European Commission

- Hydrometallurgy project for recycling components of electric vehicle batteries, which Orano is developing in France, has been declared a **strategic project by the European Commission within the framework of the Critical Raw Materials Act** (CRMA), alongside 46 other European industrial projects.

Neomat CAM project designated **"Net Zero Strategic Project"** within the framework of the **Net Zero Industrial Act** (NZIA) (UE) 2024/1735

- Several administrative steps for **CAM** phase 1 have been completed

- **Final investment decision** for CAM phase 1 plant in March 2026

European Commission

What does Europe need to make this industry thrive?

1 Long Term Vision

Through LT contracts to secure Volumes

2 Financial Support

Public and Private support

3 Regulatory Framework

Stable and supportive

Conditions for success

… to establish the complete battery value chain in Europe,

Orano & Neomat are fully committed to this!

Thank you!

Justo GARCIA
Head of Financing Strategy – Battery Program