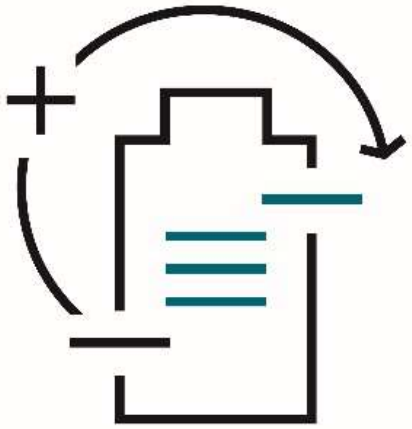


An innovative solution for battery recycling

7e Congrès trinational climat-énergie de la Conférence du Rhin supérieur

Workwhop on Green batteries and circular economy

Strasbourg
October, 6 2022

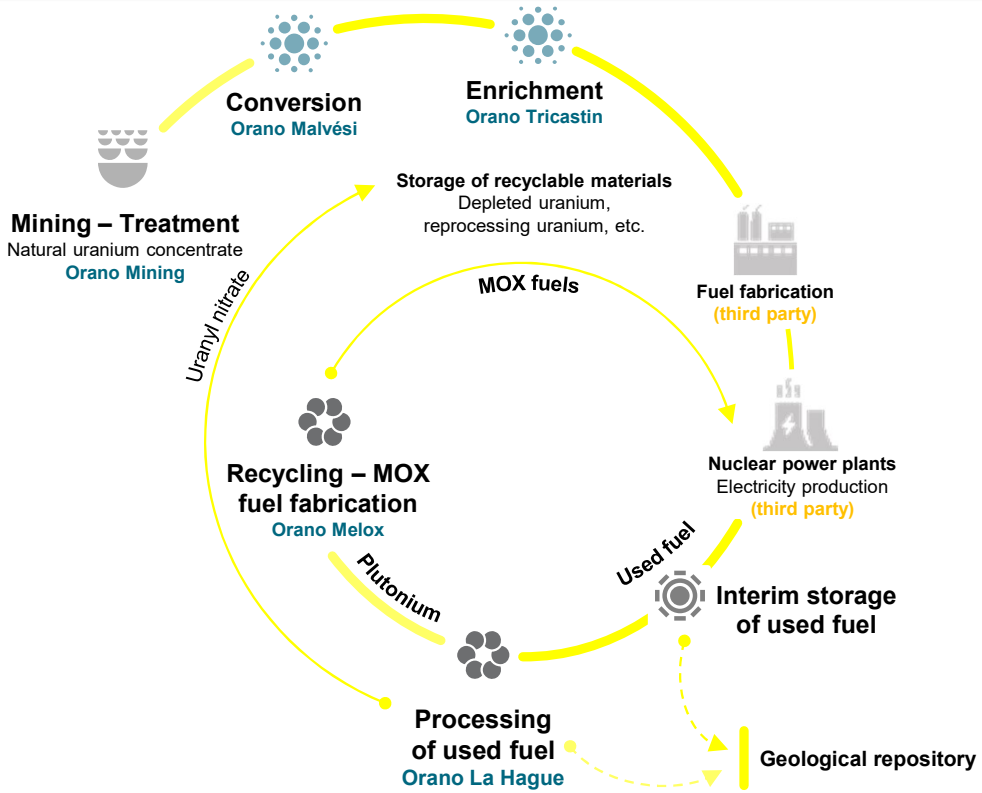
Summary

Orano profile

01

Orano is positioned across the nuclear fuel cycle from mining through to decommissioning

Fuel cycle activities



Service activities

- Nuclear Packages & Services
- Projects
- Decommissioning & Services

Nuclear Medicine

- Orano Med

Orano is striving to expand in low carbon economy and the recycling of strategic materials for the energy transition

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Orano aims to leverage its know-how to tackle the battery recycling challenges

	Description	Mining	Uranium conversion and enrichment	Used fuel recycling	Nuclear Packages and services	Engineering
1 Metal chemistry expertise	■ Development of extractive chemical metallurgy technologies	✓	✓	✓		✓
2 Inerting systems expertise	■ Design of inerted environment to avoid accidents & explosions		✓	✓		✓
3 Containment	■ Efficient risk management linked to dangerous materials		✓	✓	✓	✓
4 Production tool flexibility	■ Ability to adapt the industrial processes	✓		✓		✓
5 Transport	■ Design of nuclear transport packages & logistics for complex transports	✓			✓	✓

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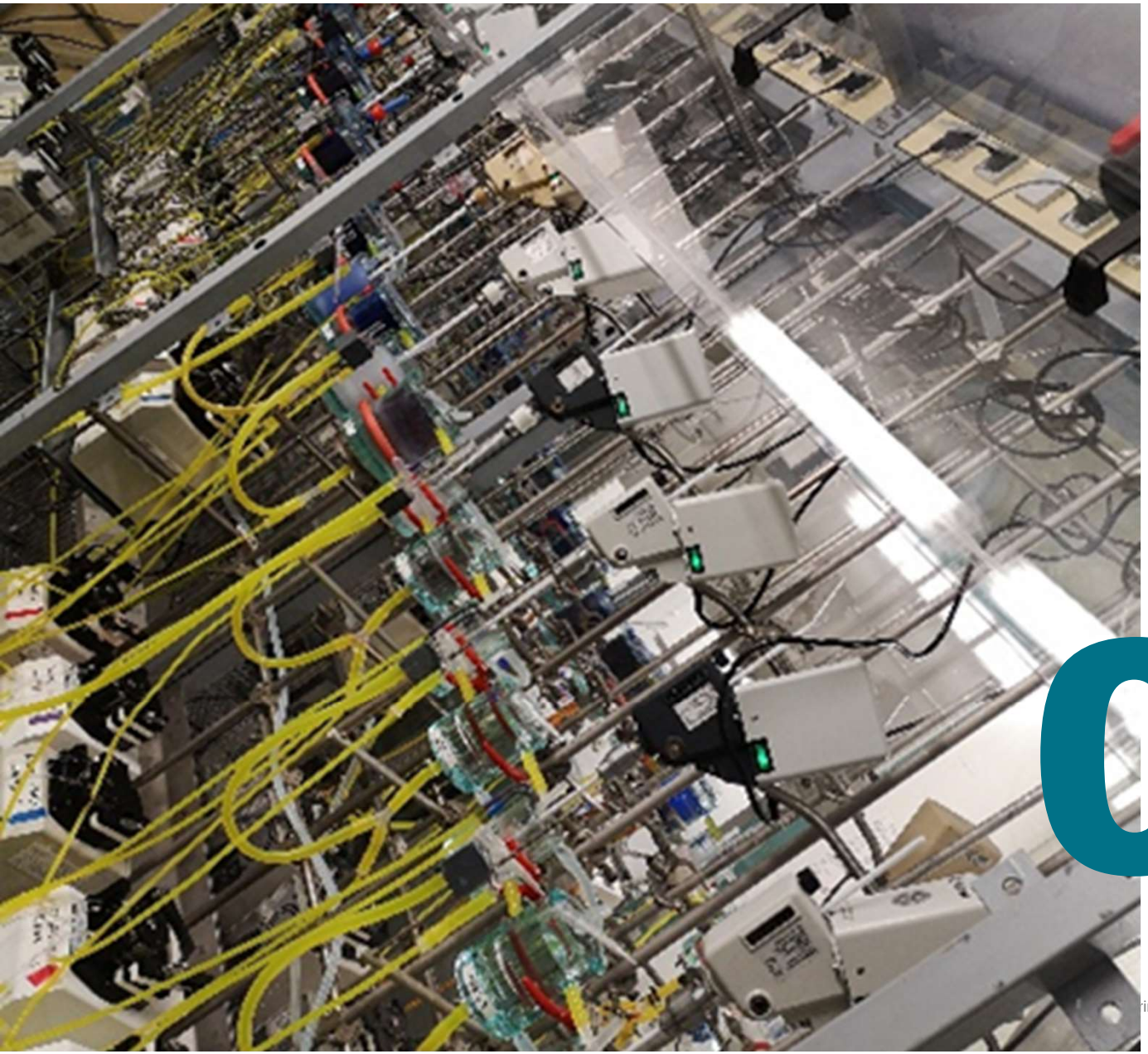

re solution

the disruptive process for batteries recycling

02

Orano and CEA have launched a strategic partnership with a joint R&D facility for the development of a disruptive battery recycling process

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Expertise

- Recycling of chemical, toxic and radioactive materials for 40 years
- Ability and skills for developing, optimizing and industrializing chemistry processes
- Strong knowledge and know-how in hydrometallurgy

Industrial assets

CIME (Bessines, France) : expertise in mineral chemical extraction

→ **30M€ investment for a new hall**

https://www.orano.group/cime

HRB (Beaumont La Hague, France) :
3 main fields of expertise in mechanical, chemistry and new technologies industrialization

liten cea tech

Expertise

- Involvement in lithium-ion batteries development for 30 years
- Pilot line compounds synthesis to pack assemblies
- Expertise in materials recycling
- Patents

R&D assets

CEA Liten (Grenoble, France) : world class technological platforms, specialized in green transition technologies

→ **Joint R&D laboratory with Orano**

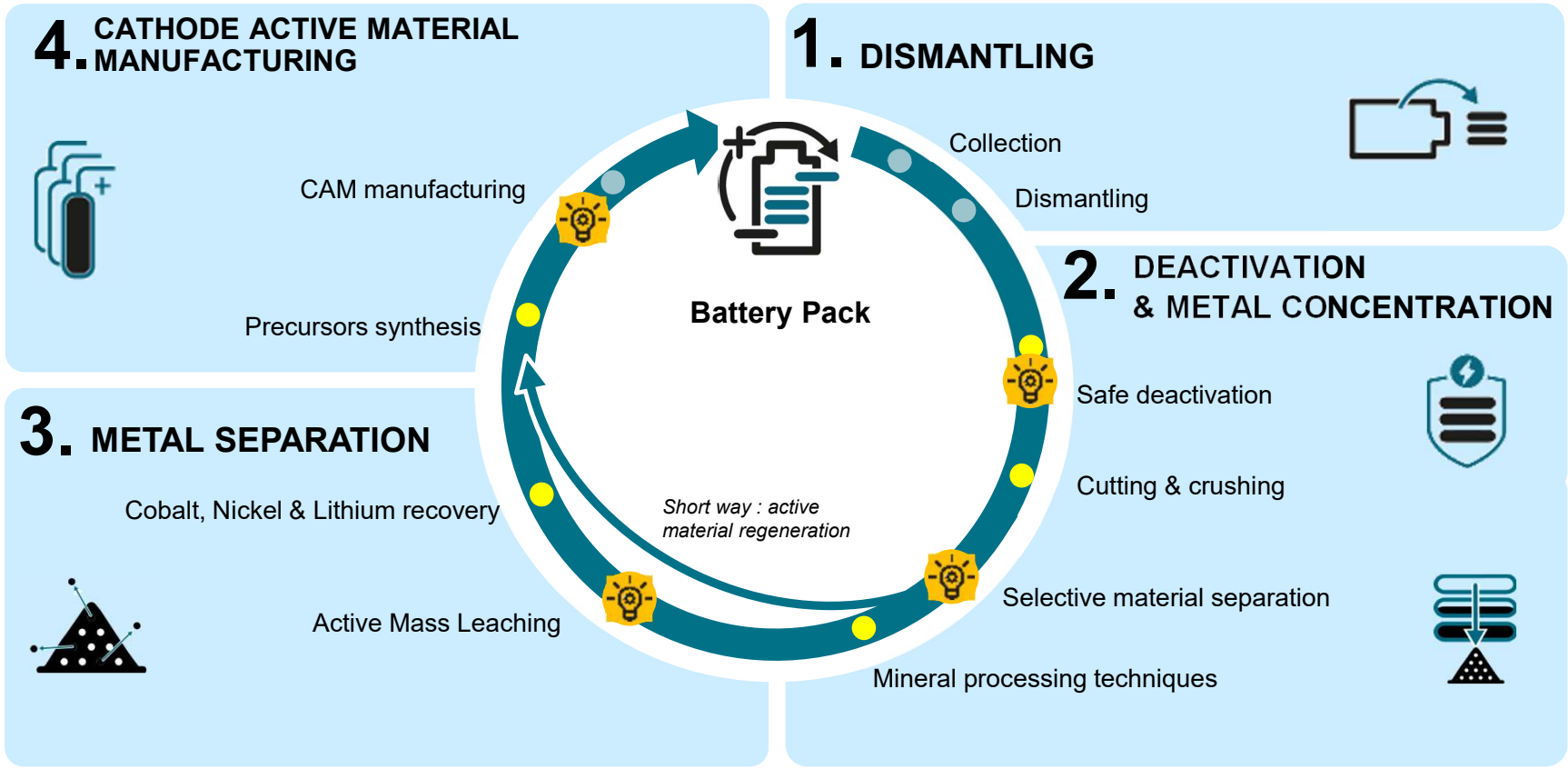
https://liten.cea.fr

A disruptive process for battery recycling

- **No pyrometallurgy** in the whole process
- Process could apply to all **EV battery chemical compositions**
- Objective to get a **high purity of recycled materials,** reusable in the EV battery cycle
- All process stages include **innovation and patents**

orano resolution

REsolutION is an efficient & cost-effective recycling process fully integrated in the closed loop of lithium-ion battery



Orano's activities Partners' activities Innovations & patents

The main key drivers of REsolutION: an efficient process able to closed the loop of the batteries

A Safe process

- **Disruptive way to safely** deactivate the module : avoid thermal treatment, no gas generation, no explosion
- Battery discharge at **module level**
- Low-cost process with no reactive consumption

An efficient Process

- **A versatile process** for all chemistries : NMC, NCA, LCO, LFP
- Recovery of all materials: active materials (Ni, Co, Mn, Li), Graphite, Al, Cu, Fe, plastics, electrolyte
- Low GHG emission

High recovery rate process

- High recovery rate Graphite recovery and Al, Cu and Fe removal
- High purity active mass production
- Recovery of battery grade salts

SRA targets 2020	SRA targets 2030	RESOLUTION		
Overall > 50%	Overall > 60%	Overall > 90 %	Additionally	Graphite >95%
Co> 90%	Co> 95%	Co > 95%		Electrolytes > 50%
Ni> 90%	Ni> 95%	Ni > 95%		Mn > 90%
Li > 35%	Li > 70%	Li > 75%		Al > 90%
Cu> 90%	Cu> 95%	Cu > 95%		Plastics >90%

- Recycled materials **reusable** in the EV battery cycle
- Enable to comply with **circular economy** and EU objectives

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Status of the development activities

03

REsolutION project benefits from regional, national and European funding

Regional

Grant from the Nouvelle Aquitaine region

- Implementation of the pilot on the CIME site in Bessines-sur-Gartempe
- Pilot equipment for pre-treatment and hydrometallurgy

National

French Recovery plan – resilience component: RECYVABAT
3-year project

- upscaling from laboratory to industrial pilots
- Synthesis of precursors
- Cell manufacturing and performance testing
- Investments in equipment & infrastructure (secure storage site)

European

Grants from Horizon Europe

BATRAW (IA)
4-year project
- 18 European partner
- Testing, reuse, dismantling and recycling
- Optimization of pre-treatment bricks
- Demonstration of process versatility
- 2 pilots : dismantling & recycling

RESPECT (RIA)
4-year project
- 18 European partners
- Alternative pre-treatment brick
- Validation of pilot versatility using different feeds (modules…)
- Validation of precursors synthesis

ReSolution | Current project status

- Working in a consortium, Orano and its R&D partners have developed a **safe and ecofriendly process** that deactivates the battery modules, recovers and purifies the metals contained in EV batteries (i.e., graphite, lithium, cobalt and nickel) so that they can be reused in new EV battery components.

- **Two industrial pilot plants are under construction** on the Orano site in Bessines-sur-Gartempe (France) to confirm this new process. They will be fully **operational in 2022.**

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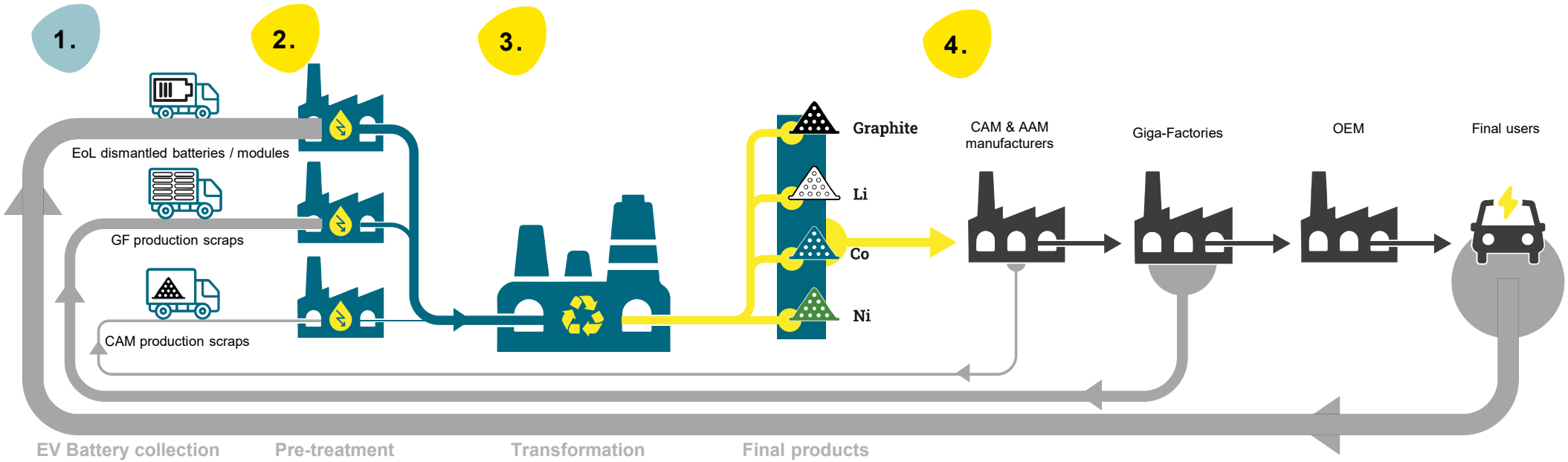
Orano positioning in batteries recycling ecosystem

04

REsolutION process enable a decentralized industrial footprint providing a reduction in both transportation cost and CO_2 footprint

Different input materials for decentralized pre-treatment units



EV Battery collection

Collection & dismantling of battery packs into modules

Pre-treatment

Local facilities dedicated to EV battery for safe deactivation, dismantling and material concentration.

Transformation

Hydrometallurgical plant able to process various incoming black mass & active mass.

Final products

To P-CAM or CAM manufacturing and / or cells / modules / EV battery manufacturing facilities.

> **Transport costs as well as GHG emissions are strongly reduced ➔ gain of 80% of total transported weight**

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Orano is on track to enter the electric vehicle battery recycling sector by 2025 with a roadmap from the lab to the large-scale industrial plant

Operational ramp-up

- 2025-2030 → 100,000 to 130,000 batteries treated with ReSolution's recycling process

- 2030-2035 → 200 000 to 260 000 batteries treated

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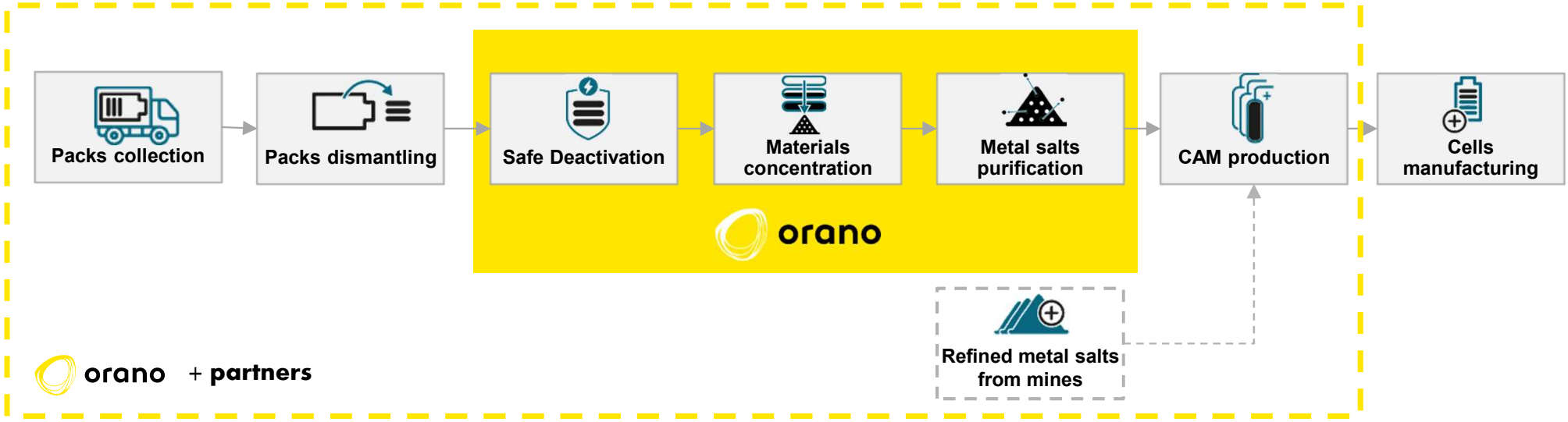
Developing a partnership strategy in batteries recycling ecosystem

Our target is to raise with partners a leading player in Li-Ion batteries in France and on European market, offering notably full hydrometallurgical process for materials of interest retrieving, and ready to operate by 2025.



REsolutION | the disruptive solution for EV battery recycling

A new, safe and disruptive hydrometallurgical recycling process

- Fewer CO2 emissions without the use of pyrometallurgycal step.
- Safe pre-treatment step to fully deactivate the EV batteries.
- Process applicable to all EV battery compositions.
- High purity output to allow a closed-loop solution in the battery cycle, compliant with the forthcoming European directives.

An industrial project deployed at the European scale

The process, fully operational by 2025, includes decentralized pre-treatment facilities allowing deactivation, dismantling and material concentration, further reducing environmental impact and costs by simplifying transportation to a central hydrometallurgical plant (reduction of 80% of total transported weight).

Contacts

05

Contacts

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