

Mobility Transformation

Circularity for critical metals



SPEAKER

Kurt Vandeputte

Capture profitable growth in circular battery value chain with **Battery Recycling Solutions**



Agenda

1.
**Mobility
transformation
driving growing
battery recycling
needs**

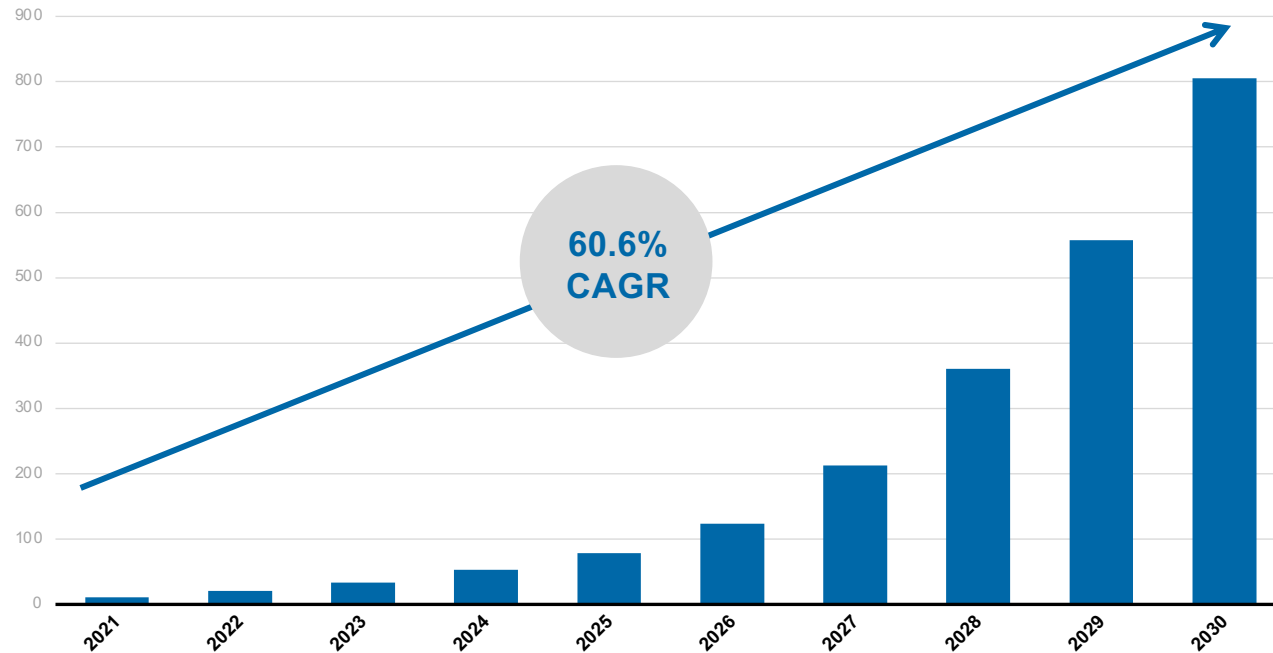
2.
**Frontrunner gearing
up for profitable
growth**

3.
RISE 2030



End-of-life EV batteries surging in the second half of the decade

End-of-life EV batteries theoretically available for recycling (kMT, global)



Business models for end-of-life vehicle disposal nascent; parameters and conditions not yet fully known

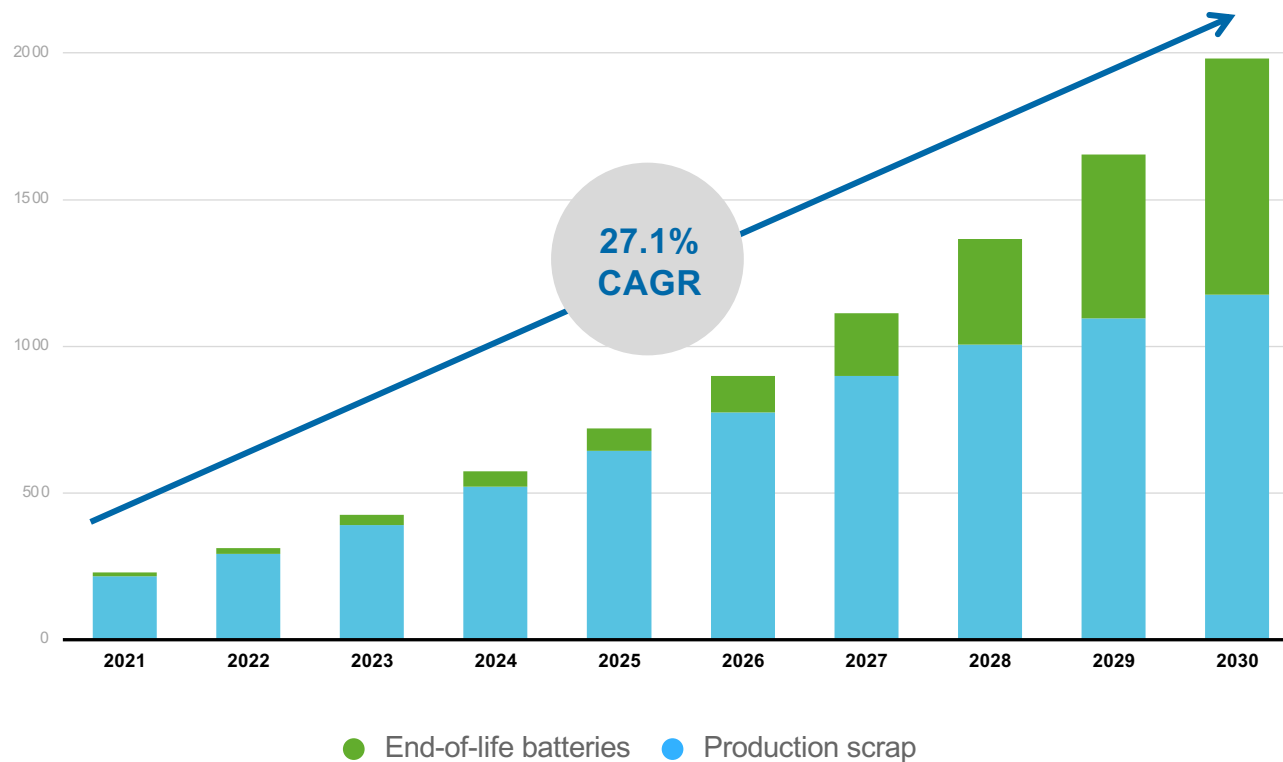
Recycled content requirements in battery production accelerating circularity pressure for critical elements (Ni, Li, Co)



Source: Umicore forecast data

Production scrap primary source of supply towards 2030

End-of-life EV batteries and production scrap available for recycling (kMT, global)



Continuous startup of battery plants expected to produce significant pre-consumer scraps

Diverse and complex input feed mix

Diversified, flexible and robust recycling technology crucial

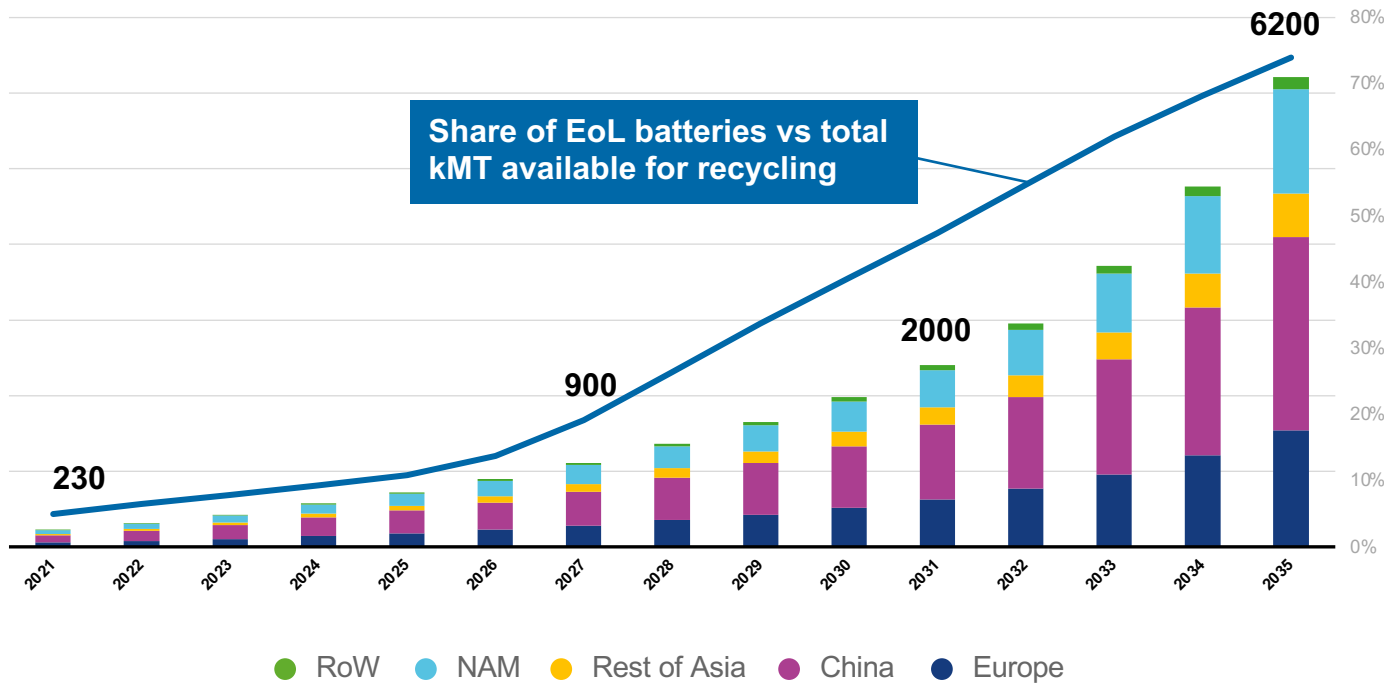


Source: Umicore forecast data

Global recycling need accelerating significantly post 2030

Robust technology to cope with feed mix changes

End-of-life EV batteries and production scrap available for recycling – per region (kMT, global)



From 2030 end-of-life expected to become the vast majority of supply feed

Regional markets expected to emerge with specific dynamics (differentiated applications and battery technologies, regulation,...)

Importance of tuning offering for the different regional markets



Source: Umicore forecast data

Recycling is crucial for the mobility transformation...

Recycling as critical additional source of supply

**SECURING
RAW
MATERIALS**

**MAJOR
ESG
ADVANTAGES**

Multiple use of minerals versus single use of fossil fuels

Upcoming recycled content targets for new battery production

Proven and traceable sustainably sourced metals (battery passport)

Enabling regional supply chains and critical material price visibility

Mandatory End-of-Life battery recycling

Reduces the need for primary natural resources

Recycled material up to 96% lower CO2 footprint vs primary materials



...requiring critical competences and skills for battery recyclers to succeed

Process



Effective volume & mass reduction at massive scale (> 100kt/y)

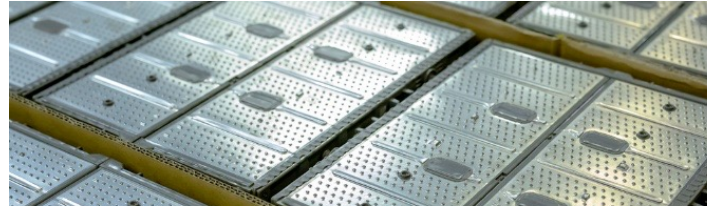
High metal extraction yields

Capable to process complex feed mix

Sustainable process:

- Safe elimination of hazardous compounds
- Manage occupational health exposure risk
- Low environmental impact

Product



Output of high-quality battery grade materials (no downcycling)

Realize effective compatibility with existing primary CAM-flowsheet

Products for high-volume addressable markets

Services



Capability to collect and treat a wide variety of materials (production scrap, off-spec components, end-of-life batteries, modules, cells, black mass)

Closed-loop operating system offering our partners a user-friendly interface and compliancy information

Competence center with integrated offering – “design for circularity”



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Capture profitable growth in circular battery value chain

Where to play

Scale up as frontrunner in Europe and prepare industrial presence in North-America

Ambition to build a 150 kt plant in **Europe by 2026** and prepare for **North-America** entry

Leverage the optimal pyro-hydro balance as differentiating technology

Combining proprietary state-of-the-art pyro- and hydro-metallurgical processes to recycle a wide variety of batteries and production scraps in the most sustainable way

Attract multiple sources for short- and long-term feed

EV-battery production scraps in short-term

End-of-Life EV-battery volumes to rapidly scale in mid-term

Complemented by end-of-life portable electronics

How to win

R

Reliable
Transformation
Partner

I

Innovation
& Technology
Leader

S

Sustainability
Champion

E

Excellence
in execution



Capture profitable growth in circular battery value chain



R

Reliable
Transformation
Partner

**SUPPORTING OUR CUSTOMERS WITH A
CIRCULAR OFFERING FROM THE START,
READY TO ACCELERATE TOGETHER**

Industrial-scale operation since 2011

Reliable transformation partner in an emerging market



R

Industrial-scale operation since 2011



Pioneering technology for portable electronics and automotive recycling validation

Highest accumulated industrial-scale experience in industry demonstrated by >15 commercial partnerships with leading OEMs and cell makers

Significant technology upgrade and debottlenecking will be gradually introduced starting in H2 2022





Reliable transformation partner in emerging market

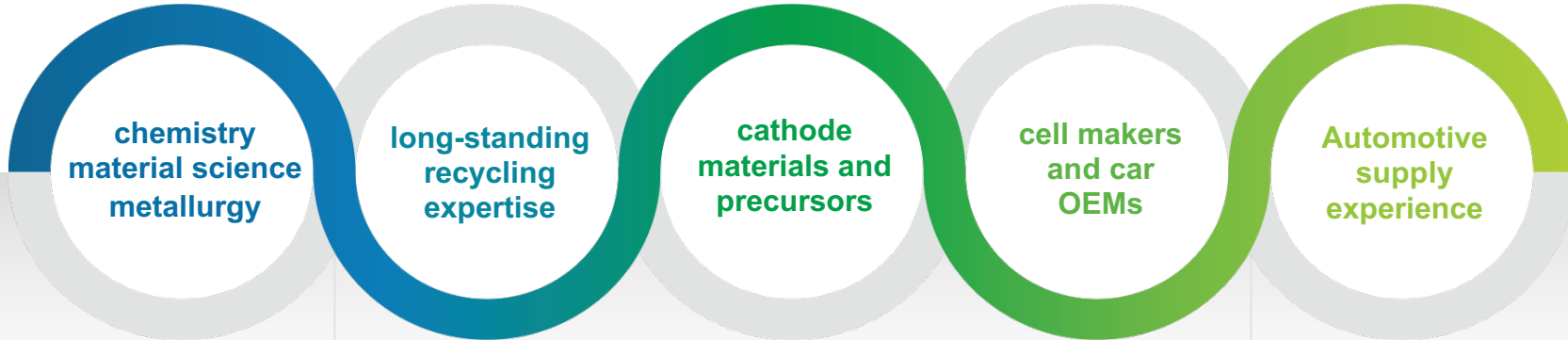


Total solution provider for production scrap and end-of-life

Unique integrated value offering through closed-loop business model

Combined knowledge and expertise in all stages of the battery value chain

REGULATORY EXPERTISE



chemistry
material science
metallurgy

long-standing
recycling
expertise

cathode
materials and
precursors

cell makers
and car
OEMs

Automotive
supply
experience

Operations and
technical know-how

Product and materials knowledge
in design for circularity

Customer
intimacy

Strategic partnerships upstream and downstream



Capture profitable growth in circular battery value chain



SCIENCE MEETS BUSINESS: LONG-STANDING MATERIALS AND PROCESS TECHNOLOGY KNOW-HOW

Pyro-hydro metallurgy process:
combining best of both worlds

Benchmarking recovery and valorization rate

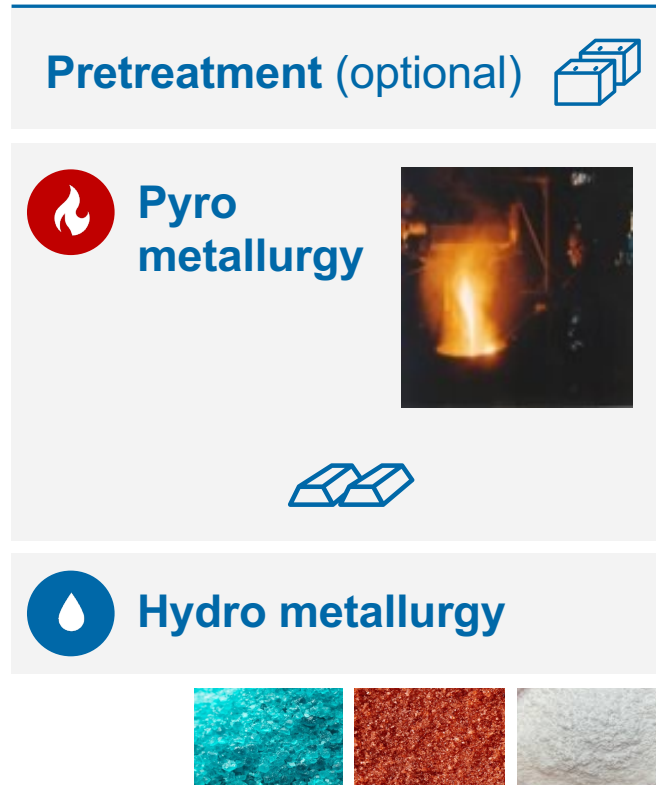




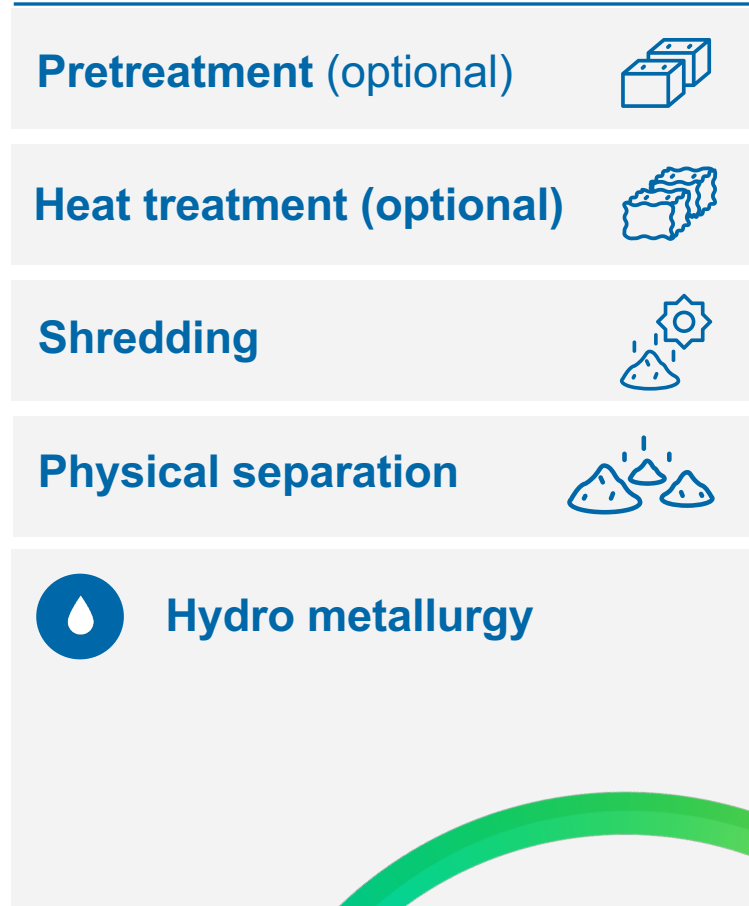
Leveraging historical competence

Resulting in a simple and highly scalable process

Umicore



Others



- Combining high-temperature and wet chemical process steps mandatory to meet all key requirements
- Pyro-step efficiently reduces complexity in a unique way
- Proprietary Umicore technology covered by more than 20 patents of which already 15 granted





Umicore's battery recycling technology



Mastering the pyro-hydro metallurgy optimum

Combining proprietary state-of-the-art pyro- and simple hydro-metallurgical processes to recycle wide variety of batteries and production scraps in most sustainable way

Input flexibility	Process and yields	Investment and cost	ESG considerations
<p>Central to the ecosystem: battery modules, individual cells, battery cell production scraps and black mass from battery shredding</p> <p>Minimal pre-treatment steps</p> <p>Hazardous chemicals decomposed and fully eliminated</p>	<p>Reliable, robust and proven with > 10 years experience</p> <p>Building on > 20 years expertise in Precious Metals Refining</p> <p>Maximum yields of valuable metals – battery grade output</p> <p>Extract more metals with high lithium recovery rates</p>	<p>20% to 30% lower capital investment versus other technologies</p> <p>35% lower opex:</p> <ul style="list-style-type: none"> - low energy cost - low reagent cost <p>Highest value creation</p>	<p>Better or similar to hydro set-ups from overall ESG perspective</p> <ul style="list-style-type: none"> • Limited footprint • Lowest GHG/easier to decarbonize • Lowest emissions to air & water <p>Supported by LCA studies</p>





Benchmarking recovery and valorization rates closing the loop

Umicore process technology future legislation proof, regardless of feed mix

- **End-to-end recycling rate >95% for Ni, Co, Cu and >70% for Li**
 - setting industry standards
 - from a large variety of complex materials
 - battery grade quality recovered metals

- **Closing the loop by supplying recycled content to Umicore's CAM production in line with future regulatory requirements**



EU battery regulation

	Now	2025/26	2030
Battery recycling efficiency (%)	>50	>65	>70
Material Recovery Rate Ni/Co (%)	NA	>90	>95
Material Recovery Rate Li (%)	NA	>35	>70



Capture profitable growth in circular battery value chain



KEY ENABLER FOR THE CIRCULAR ECONOMY

**Embedded sustainability value
through sustainable recycling operations**

Responsible and circular sourcing

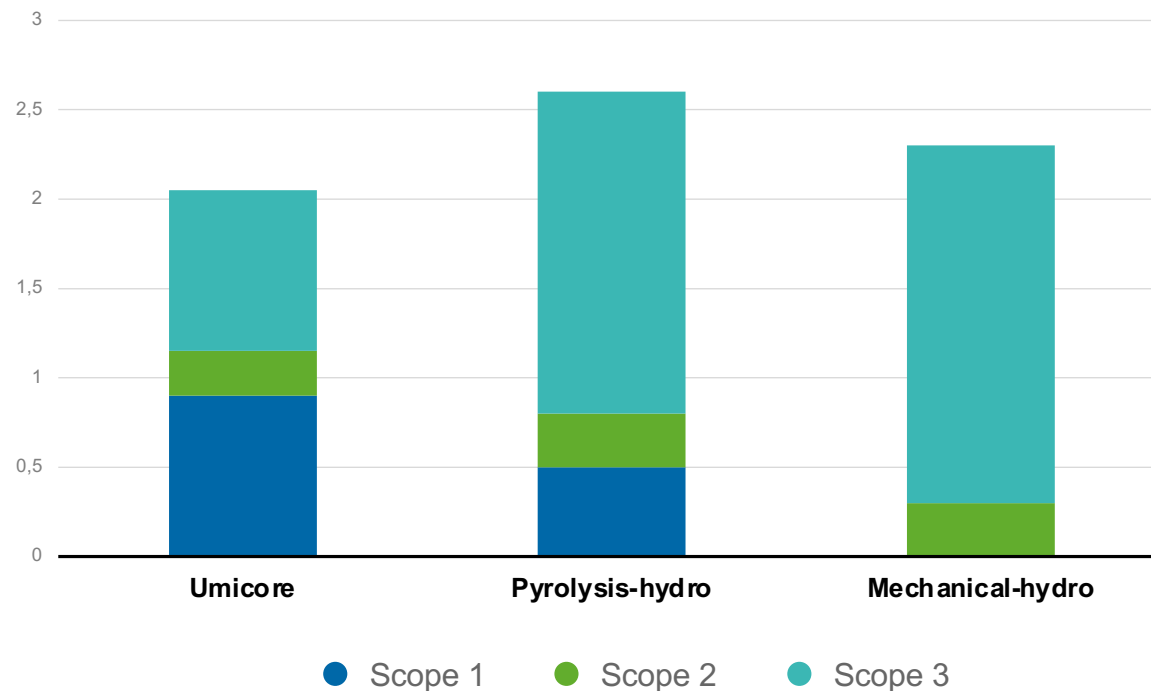


Embedded sustainability value

Through sustainable recycling operations

Scope 1, 2 & 3 emissions profile

kg CO₂e/kg module equivalent



Leveraging technological knowhow for lowest overall impact

- Lowest CO₂ footprint
- Lowest energy needs
- Lowest waste generated
- Carbon neutral battery recycling by 2035

Addressing resource scarcity & answering sustainability needs

- Meeting the growing demand for battery metals
- Recycled material has up to 96% lower CO₂ footprint vs primary materials



The results are an extract of comparable LCA-analyses performed according the ISO14040/44 standard and thus validated by a competent third party

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Responsible and circular sourcing

Leveraging our closed-loop



Closing the materials loop in our battery value chain

Battery Recycling Solutions key to decarbonize the battery value chain upstream and downstream

Maximizing traceability

Leveraging our position in the value chain as part of our commitment to ensure sustainable and responsible sourcing



Capture profitable growth in circular battery value chain



E

Excellence
in execution

SCALABLE TECHNOLOGY DELIVERING ON MARKET REQUIREMENTS

Over 10 years of pilot scale experience gives a head start to scale to 150kt capacity units

Linking diverse supply to very stringent material specifications



E

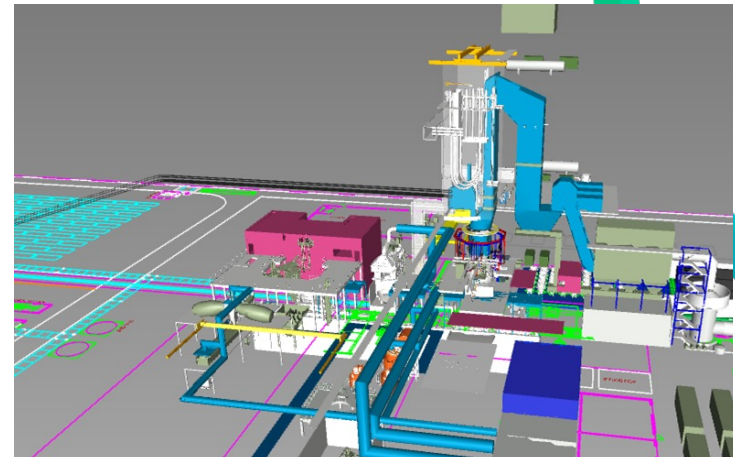
Frontrunner ready to accelerate Scale in Europe, prepare presence in North America

Europe

- Growing from a strong existing asset base in Belgium
- Engineering of 150kt-unit on accelerated path
- Process technology upgrade implementation

North America

- Industrial presence in planning phase
- Following market growth through two-step industrialization
- Industrial synergies possible between North America and Europe during market uptake





Linking variability with product consistency

Robust recycling technology is crucial



Variability in battery recycling mix is a fact

Different battery types

Strongly diversified applications

Production scrap and EoL-batteries mix

CAM quality consistency is a must

Battery grade purity and quality is critical

High-volume supply streams are mandatory

Full traceability required



Product and process technology competences form the basis of performant industrial execution path



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Battery Recycling Solutions – RISE

Capture profitable growth in circular battery value chain



Establishing Battery Recycling Solutions as key enabler for a circular and low-carbon battery value chain

umicore[®]

materials for a better life