Mobility Transformation

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

SPAKER
Kurt Vandeputte
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

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

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

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

Mandatory End-of-Life battery recycling

Proven and traceable sustainably sourced metals (battery passport)

Reduces the need for primary natural resources

Enabling regional supply chains and critical material price visibility

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”
Agenda

1. Mobility transformation driving growing battery recycling needs

2. Frontrunner gearing up for profitable growth

3. RISE 2030
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

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

Reliable Transformation Partner

- Industrial-scale operation since 2011
- Reliable transformation partner in an emerging market
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

- Chemistry material science metallurgy
- Long-standing recycling expertise
- Cathode materials and precursors
- Cell makers and car OEMs
- Automotive supply experience

Strategic partnerships upstream and downstream

Operations and technical know-how
Product and materials knowledge in design for circularity
Customer intimacy
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

<table>
<thead>
<tr>
<th>Umicore</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretreatment</td>
<td>Pretreatment (optional)</td>
</tr>
<tr>
<td>Pyro metallurgy</td>
<td>Heat treatment (optional)</td>
</tr>
<tr>
<td>Shredding</td>
<td>Physical separation</td>
</tr>
<tr>
<td>Hydro metallurgy</td>
<td>Physical separation</td>
</tr>
</tbody>
</table>

- 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

<table>
<thead>
<tr>
<th>Input flexibility</th>
<th>Process and yields</th>
<th>Investment and cost</th>
<th>ESG considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central to the ecosystem: battery modules, individual cells, battery cell production scraps and black mass from battery shredding</td>
<td>Reliable, robust and proven with &gt; 10 years experience</td>
<td>20% to 30% lower capital investment versus other technologies</td>
<td>Better or similar to hydro set-ups from overall ESG perspective</td>
</tr>
<tr>
<td>Minimal pre-treatment steps</td>
<td>Building on &gt; 20 years expertise in Precious Metals Refining</td>
<td>35% lower opex:</td>
<td>• Limited footprint</td>
</tr>
<tr>
<td>Hazardous chemicals decomposed and fully eliminated</td>
<td>Maximum yields of valuable metals – battery grade output</td>
<td>- low energy cost</td>
<td>• Lowest GHG/easier to decarbonize</td>
</tr>
<tr>
<td></td>
<td>Extract more metals with high lithium recovery rates</td>
<td>- low reagent cost</td>
<td>• Lowest emissions to air &amp; water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Highest value creation</td>
<td>Supported by LCA studies</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th></th>
<th>Now</th>
<th>2025/26</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery recycling efficiency (%)</td>
<td>&gt;50</td>
<td>&gt;65</td>
<td>&gt;70</td>
</tr>
<tr>
<td>Material Recovery Rate Ni/Co (%)</td>
<td>NA</td>
<td>&gt;90</td>
<td>&gt;95</td>
</tr>
<tr>
<td>Material Recovery Rate Li (%)</td>
<td>NA</td>
<td>&gt;35</td>
<td>&gt;70</td>
</tr>
</tbody>
</table>
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 CO$_2$e/kg module equivalent

Leveraging technological knowhow for lowest overall impact
- Lowest CO$_2$ 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 CO$_2$ 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.
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

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
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

<table>
<thead>
<tr>
<th>Variability in battery recycling mix is a fact</th>
<th>CAM quality consistency is a must</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different battery types</td>
<td>Battery grade purity and quality is critical</td>
</tr>
<tr>
<td>Strongly diversified applications</td>
<td>High-volume supply streams are mandatory</td>
</tr>
<tr>
<td>Production scrap and EoL-batteries mix</td>
<td>Full traceability required</td>
</tr>
</tbody>
</table>

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

1. Mobility transformation driving growing battery recycling needs
2. Frontrunner gearing up for profitable growth
3. RISE 2030
Battery Recycling Solutions – RISE
Capture profitable growth in circular battery value chain

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>I</th>
<th>S</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reliable Transformation Partner</td>
<td>Innovation &amp; Technology Leader</td>
<td>Sustainability Champion</td>
<td>Excellence in execution</td>
</tr>
<tr>
<td>Support</td>
<td>SUPPORTING OUR CUSTOMERS WITH A CIRCULAR OFFERING FROM THE START, READY TO ACCELERATE TOGETHER</td>
<td>SCIENCE MEETS BUSINESS: LONG-STANDING MATERIALS AND TECHNOLOGY KNOW-HOW</td>
<td>KEY ENabler FOR THE CIRCULAR ECONOMY</td>
<td>SCALABLE TECHNOLOGY DELIVERING ON MARKET REQUIREMENTS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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

Leverage the optimal pyro-hydro balance as differentiating technology

Attract multiple sources for short- and long-term feed
materials for a better life