Precious Metal Refining
VFB Site Visit
14 November 2017
One of three global leaders in emission control catalysts for light-duty and heavy-duty vehicles and for all fuel types

A leading supplier of key materials for rechargeable batteries used in electrified transportation and portable electronics

The world’s leading recycler of complex waste streams containing precious and other valuable metals
Our foundations

Unique business model
- metals
- application know-how
- material solutions
- recycling
- Chemistry material science metallurgy

Supportive megatrends
- more stringent emission control
- electrification of the automobile
- resource scarcity

Industry leader in sustainability

Chemistry
material science
metallurgy

Material solutions

Recycling

More stringent emission control

Electrification of the automobile

Resource scarcity
Our Group structure

CATALYSIS
- Automotive Catalysts
- Precious Metals Chemistry

ENERGY & SURFACE TECHNOLOGIES
- Cobalt & Specialty Materials
- Rechargeable Battery Materials
- Thin Film Products
- Electroplating
- Electro-Optic Materials

RECYCLING
- Precious Metals Refining
- Jewellery & Industrial Metals
- Platinum Engineered Materials
- Precious Metals Management
- Technical Materials
Our Strategy – Horizon 2020

By 2020 we expect to have…

- Doubled the size of the business in terms of earnings
- Clear leadership in clean mobility materials and recycling
- Rebalanced the portfolio & earnings contributions
- Turned sustainability into a greater competitive edge
Unique position in clean mobility materials

- Incumbent
- Early stage

<table>
<thead>
<tr>
<th>Umicore</th>
<th>Automotive catalysts</th>
<th>Battery materials</th>
<th>Fuel cell catalysts</th>
<th>Recycling services</th>
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- Automotive catalyst competitors: ✔️ ✔️ ✔️ ✔️
- Battery material competitors: ✔️ ✔️ ✔️
- Fuel cell catalyst competitors: ✔️ ✔️ ✔️

Grow faster than the market in LDV and HDD

Clear leadership in cathode materials for xEV
Unique position in recycling

**Unique technologies in Hoboken** for treating complex residues and by-products

**Over 200** input streams

**Recovery of 20 metals**
Doubling the earnings

RECURRING EBIT

Excluding Discontinued

Potential to double earnings from 2014 base

CAGR ~10%

Increase ROCE to beyond 15% target
Rebalancing the portfolio

More significant relative contribution expected from both Catalysis and Energy & Surface Technologies in 2020
Sustainability as a competitive edge

Upstream
- Sustainable supply

Eco-efficiency
- Safety

Health
- People engagement

Downstream
- Sustainable products and services

Turned sustainability into a greater competitive edge
The Recycling Business Group
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<tr>
<td>Operates the world’s most sophisticated precious metals recycling facility and recovers 17 precious and other valuable metals from complex waste streams. Proprietary technology for the recycling of Li-ion rechargeable batteries.</td>
<td>Supplier of precious metals creating products for the jewellery sector and industrial applications as well as recycling old jewellery and production scrap.</td>
<td>Specialist in the development and manufacturing of PGM based gauzes and components for the special glass and chemical industries.</td>
<td>Services for hedging, leasing, purchasing and sale of precious metals to internal and external customers.</td>
<td>Supplier of silver and other metal containing products for technical applications in the electric and power, lighting, heating-ventilation-air conditioning (HVAC) and tooling sectors.</td>
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Loops in recycling

**SHORT LOOP**
Recycling services for customer production scrap and residues

**LONG LOOP**
Unique technologies for treating complex residues and by-products

**JIM, TM and PEM**
High precious metals concentrations, sampling easier, simpler technology, integrated with product offering

**PMR**
Complex (lower precious metals concentrations, numerous metals), sampling more complex, sophisticated technology
Short loop in recycling

Precious Metals Management (PMM) sources precious metals for industrial business units.
Recycling key figures FY 2016

**Revenues**

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**Recurring EBIT**

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<td>65</td>
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(in million €)
Precious Metals Refining
Precious Metal Refining today

Largest and most complex precious metals recycling operation in the world

Processes more than 200 different types of raw materials

World leading refiner of 20 different metals

World class environmental and quality standards
The value chain of metals

- Mines
  - Ores & concentrates
  - Complex mining concentrates & residues
- Smelters & refiners
  - Smelting & refining residues
- Industry
  - Complex production scrap
- Consumers
  - New products
  - Complex end-of-life materials

Industrial by-products

Recyclables
Industrial by-products

WET
- e.g. lead sulphate

LUMPY/METALLIC
- e.g. drosses

DUSTY/FREE-FLOWING
- e.g. fine drosses

Precious Metals
- e.g. filter cake
- e.g. impure bullion
- & many more

Metallic elements:
- Lead (Pb)
- Zinc (Zn)
- Copper (Cu)
- Nickel (Ni)

PGM: Precious Metals
- e.g. hydroxide
- e.g. slags
- e.g. flue dust
- e.g. complex concentrate
- e.g. electrolysis slimes
- e.g. mattes
- e.g. fine drosses
- e.g. complex concentrate
Recycables

- **Electronic Scrap**
  - e.g. mobile phones, printed circuit boards

- **Spent Automotive Catalysts**
  - End-of-life car catalysts

- **Spent Industrial Catalysts**
  - Industrial catalysts from oil refining & petrochemical industry

- **Other precious metal bearing materials**
  - e.g. fuel cells, photographic residues

**Materials**
- Au, Ag, Pd, Cu...
- Pt, Pd, Rh...
- Pt, Pd, Rh...
- Ag, In, Se...
A global customer base

6,400 lots

>500 customers

By-products
Recyclables
Umicore is unique due to its proprietary complex flowsheet that combines three metallurgical streams.

This enables:

- Flexibility to treat a broad range of input materials
- Recovery & valorization of the most metals
- Ability to optimize feed and therefore profitability
- Scope to broaden to new types of materials in future

- Umicore technology guarantees environmentally friendly processing, a high yield and a more competitive cost
- Umicore introduced its unique Ultra High Temperature technology for Battery Recycling more than 5 years ago
The refining process

Recyclables

Collector metals

Industrial by-products

17 different metals
How PMR generates revenues

**Main revenue drivers**

**Treatment & refining charges**

Treatment charges are determined, among other criteria, by the complexity of the materials.

**Metal yield**

Umicore assumes the risk of recovery above or under the contractually agreed recovery rate.
Metal price exposure

Direct:
through metal yield

Indirect:
through raw material availability

Managing the effects of metal price movements on earnings

Systematic hedging of transactional exposure (pass through metal)

Depending on market conditions hedging of (part of) structural metal price exposure through contractual arrangement

Impact on working capital is mitigated by toll-refining – metals remain property of the supplier during treatment
**Competitive landscape**

No one can take in the wide span of materials and metals

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
<th>Products</th>
<th>Degree of overlap</th>
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<tbody>
<tr>
<td>Base metal Refiners</td>
<td>Stolberg, Penoles, Glencore, Tech Cominco, LS Nikko, Brixlegg</td>
<td>Cu, Pb, Zn by-products containing precious metals (PM)</td>
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<tr>
<td></td>
<td></td>
<td>Some e-scrap</td>
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<tr>
<td>Primary PGM Refiners</td>
<td>Stillwater, Amplats</td>
<td>Recyclables: automotive catalysts</td>
<td></td>
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<tr>
<td>Specialty PM/PGM Refiners</td>
<td>Vale, Impala, Norilsk</td>
<td>By-products rich in PM</td>
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<tr>
<td></td>
<td>JMI, BASF, Heraeus, Chimet, Tanaka, Nippon PGM, Sabin, Gemini</td>
<td>Recyclables: industrial or automotive catalysts</td>
<td></td>
</tr>
<tr>
<td>Specialized Refining Companies</td>
<td>Dowa, Boliden, Aurubis, Korea Zinc</td>
<td>Cu, Pb, Zn by-products containing PM</td>
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<tr>
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<td></td>
<td>Recyclables: electronic scrap and industrial catalysts</td>
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**Most competitors are customers**

They usually focus on niches

No other company can process as wide a scope of materials as Umicore
Long term business drivers

- Resource scarcity
- Increased complexity of materials
- Eco-efficiency

Capture more value through capacity expansion, unique technologies and new streams of recycling
Resource scarcity
Opportunity for PMR to process more metals

Increase of production of metals leads to more by-products from the base metals and PGM industry

Processing end of life products is necessary for a sustainable supply of metals

Evolution of global production level 1980-2014

Pb (m tonnes) | Zn (m tonnes) | Cu (m tonnes) | Pt (m tonnes)
Increased complexity of materials
Availability to increase for Umicore

Availability of complex concentrates on the rise which means **higher complexity of by-products from primary refiners**

Diversity and complexity in the recyclables market **limits processing of these materials** by base metals smelters

Increased pressure on non-ferrous smelters to comply with **stricter EHS guidelines**

Trading companies like Trafigura, Ocean Partners and others have made significant investments in storage and blending capacity in recent years as the volume of complex concentrates in the market have increased.

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*South American mining company, Reuters Oct 2014*

Many of the new mines currently coming on stream are producing concentrates with high levels of impurities.

*So we are actively looking at process changes and new technologies in order to cope with the complexity in a suitable manner.*

*Copper refiner, Metal Bulletin Apr 2015*
Eco-efficiency
Trends towards higher recycling rates

Base metal smelters are increasingly obliged to find an outlet for their by-products

Recycling markets of end-of-life products to increase

Processing complex materials in an environmentally friendly way will become the norm

Umicore Precious Metals Refining’s outstanding environmental performance and ethical sourcing practices provide an additional competitive edge

E-waste generated in 2014

41.8 million tonnes

Only 4 billion people are covered by national legislation

That’s approximately 4 out of every 7 people

From The Global e-waste monitor 2014, United Nations University, 2015
Growth strategy 2015-2020

- Increase in capacity
- Continuous upgrade of fixed assets base
- R&D to maintain technology leadership
- Recycling development
Capacity increase is key to growth

- Investment to increase capacity at Hoboken by 40%
- Further improvement of competitiveness through economy of scale
- Ramp-up 2016-2018
- Refining charges will initially not follow the same pace as volume growth due to material mix
Continuous upgrade of fixed asset base

Continuous improvement through investments in fixed assets will continue

Innovation remains critical in guaranteeing strong performance (environment, metal yield, cost)

Debottlenecking never stops
R&D to maintain technology leadership

PMR continues to invest heavily in R&D

Innovative process technology ensures PMR remains the leader in complex metallurgy

Battery recycling technology, introduced in 2011, is offering options for future process improvements
Recycling development

The demo plant is operational since 2011. Processing of spent rechargeable batteries optimized and validated.

The market is set to develop strongly in the coming years.

By 2020, Umicore will be ready for scaling-up to a real industrial footprint.
Hoboken plant
Hoboken plant
125 years of history

Transformation process started in late nineties
Continued process improvements and innovations since
Unique metallurgical flowsheet

**Raw materials**

- **Sulphuric acid plant**
  - SO₂
  - Ni-speiss
  - PM-residues
  - H₂SO₄

- **Smelter**
  - Cu-bullion
  - Leaching & electro winning
  - PM-residues
  - Cu-matte

- **Blast furnace**
  - Pb-slag
  - Cu-matte

- **Lead refinery**
  - In-Te-residue
  - Ag-residue

- **Precious metals refinery**
  - Ag, Au, Pt, Pd, Rh, Ir, Ru
  - Se residue

- **Special metals refinery**
  - In, Se, Te
  - Pb, Bi, Sb, Sn

- **Aggregate**

**Sampling and assaying**

- Raw materials
- Sulphuric acid plant
- Nickel refinery OLEN
- Precious metals refinery
- Special metals refinery

**Annotations**

- H₂SO₄
- Ni, As
- Cu
- Ag, Au, Pt, Pd, Rh, Ir, Ru
Precious metals operations

SMELTER
- Unique application of ISASMELT technology
- Precious metals concentrated in copper bullion

LEACHING & ELECTROWINNING
- Highly flexible technology
- Copper leaching to collect precious metals residue
- Production of pure copper cathodes

PRECIOUS METALS REFINERY
- Both classical and unique processes used
- Incorporating pyro- and hydro-metallurgy
- Production of high purity metals
Base metals operations

BLAST FURNACE
- Production of lead bullion
- Construction aggregate to construction industry in three grain sizes: Umicrock, Betogrind, Betozand

LEAD REFINERY
- Refining of lead bullion
- Production of 99.99% lead, LME-registered brand
- A major European lead producer

SPECIAL METALS REFINERY
- Refining side-stream materials from the lead and precious metals refineries
- Production of high purity metals

Pb-bullion
In-Te-residue
Eco-efficiency
Sustainability

External engagement and recognition
This presentation contains forward-looking information that involves risks and uncertainties, including statements about Umicore’s plans, objectives, expectations and intentions.

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materials for a better life