

CAPITAL  
MARKETS  
DAY **POWERING  
AHEAD**

  
**umicore**  
*materials for a better life*

**Seoul, Korea**

6 June 2018



# Increasing the gap in Rechargeable Battery Materials



**SPEAKER**

*Kurt Vandeputte*

*Senior Vice-President  
Rechargeable Battery Materials*



# Agenda

## Business profile

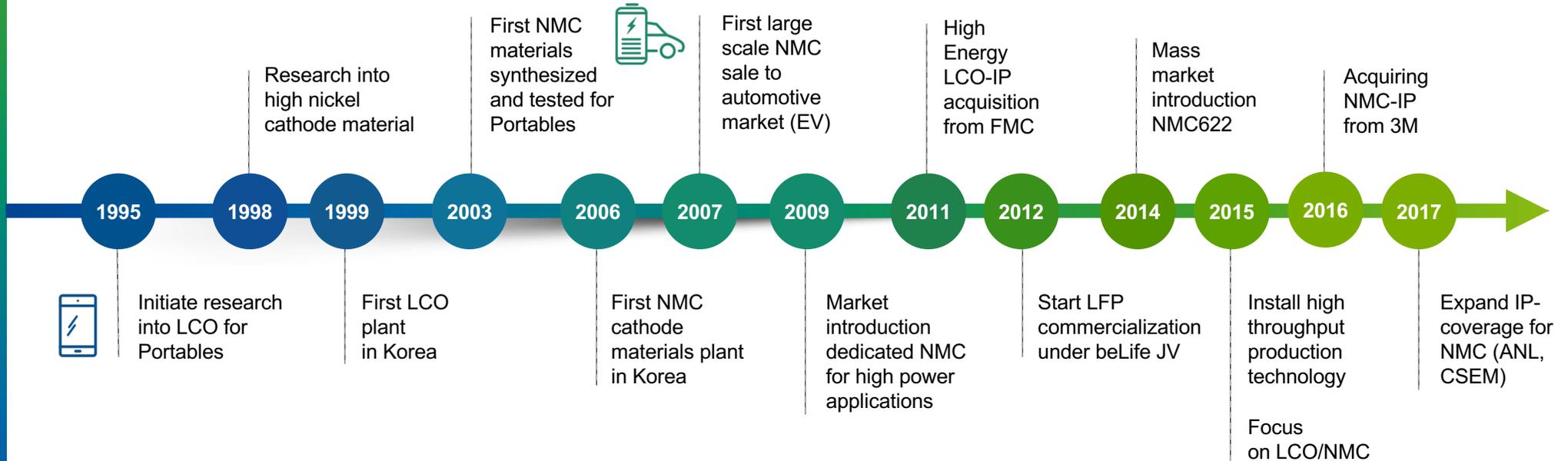
Accelerated growth in Electrification

Success factors

Key takeaways



# 20+ years of innovation in li-ion battery materials



# Business model



**Product innovation**  
based on strong  
**application know-how**



**Process innovation**  
fuels productivity  
improvements while  
maintaining highest quality  
standards (stringent  
automotive standards)



Established industrial  
footprint **close to the  
customer**

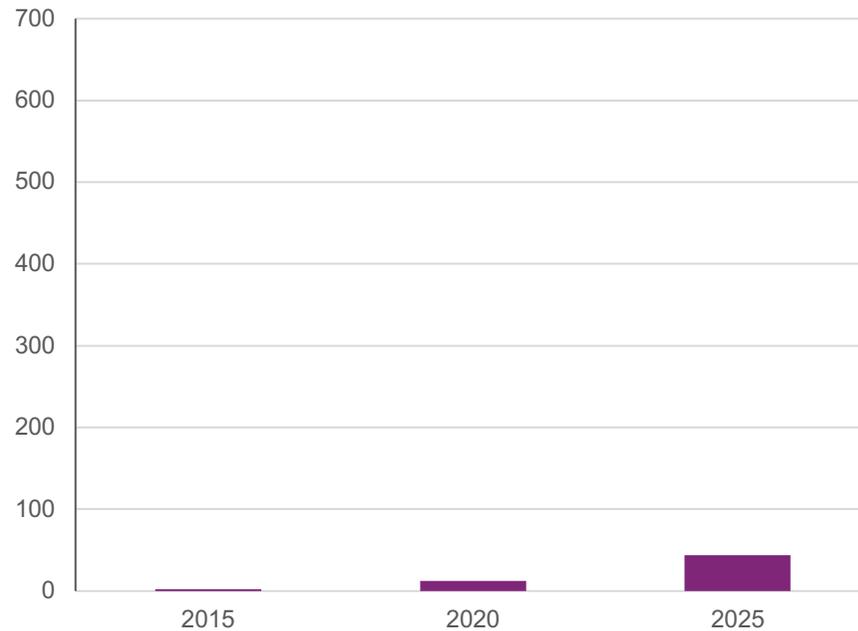


**Strong industrialization  
capabilities** building on  
historical Umicore key  
competences



Integrated process flows  
with guaranteed access  
to critical raw materials  
allows an **agile market  
approach**

# Battery market projections



RECHARGEABLE BATTERY MARKET (GWH)

ESS ●

Energy Storage System  
Regulatory driver



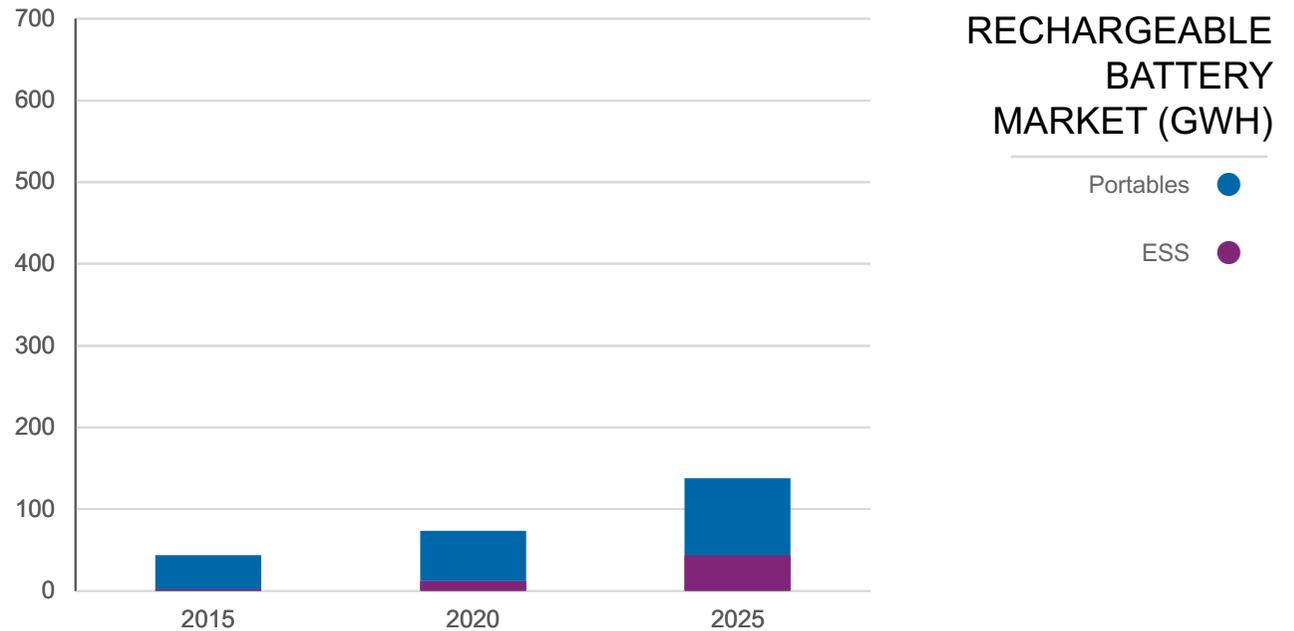
Source: Avicenne, Navigant, Roland Berger, AABC, IHS, Gartner, SNR, CRU, Roskill

# Battery market projections

**Portables**  
Societal driver



**Energy Storage System**  
Regulatory driver



Source: Avicenne, Navigant, Roland Berger, AABC, IHS, Gartner, SNR, CRU, Roskill

# Battery market projections

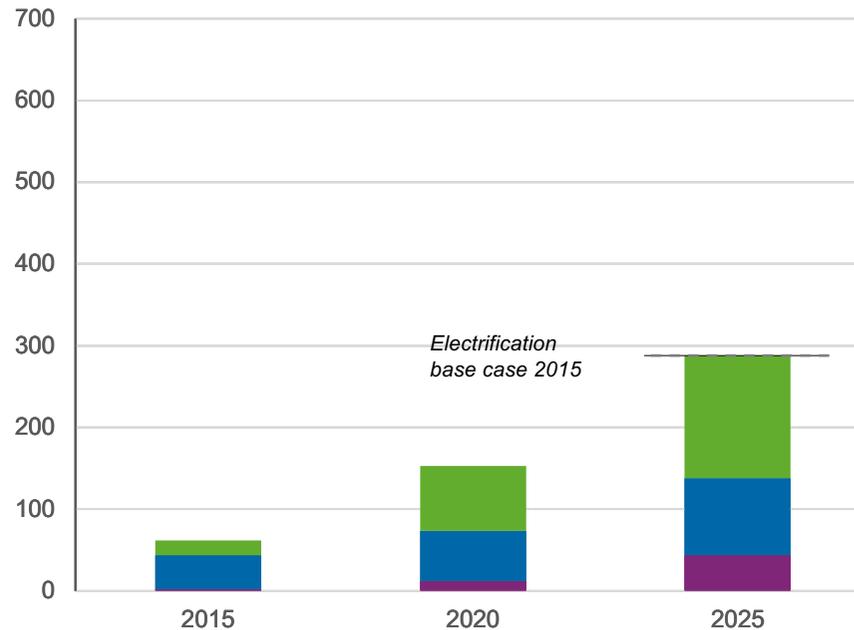
**Electrification**  
Regulatory driver



**Portables**  
Societal driver



**Energy Storage System**  
Regulatory driver



## RECHARGEABLE BATTERY MARKET (GWH)

- Electrification Base Case 2015
- Portables
- ESS

Source: Avicenne, Navigant, Roland Berger, AABC, IHS, Gartner, SNR, CRU, Roskill

# Battery market projections

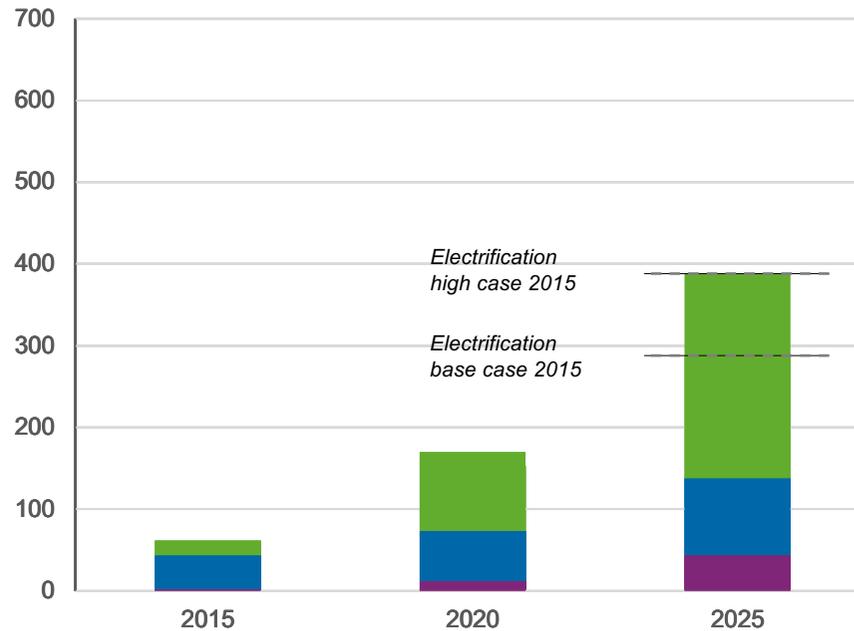
**Electrification**  
Regulatory driver



**Portables**  
Societal driver



**Energy Storage System**  
Regulatory driver



## RECHARGEABLE BATTERY MARKET (GWH)

- Electrification High Case 2015 (Green circle)
- Portables (Blue circle)
- ESS (Purple circle)

Source: Avicenne, Navigant, Roland Berger, AABC, IHS, Gartner, SNR, CRU, Roskill

# Battery market projections

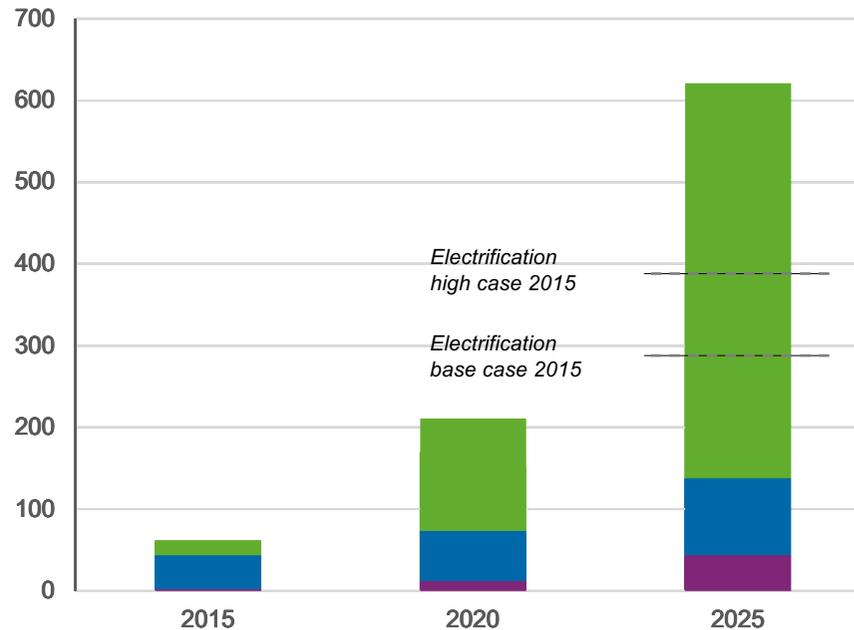
**Electrification**  
Regulatory driver



**Portables**  
Societal driver



**Energy Storage System**  
Regulatory driver



## RECHARGEABLE BATTERY MARKET (GWH)

- Electrification Current Scenario ●
- Portables ●
- ESS ●

☰ Source: Avicenne, Navigant, Roland Berger, AABC, IHS, Gartner, SNR, CRU, Roskill

# Battery market projections

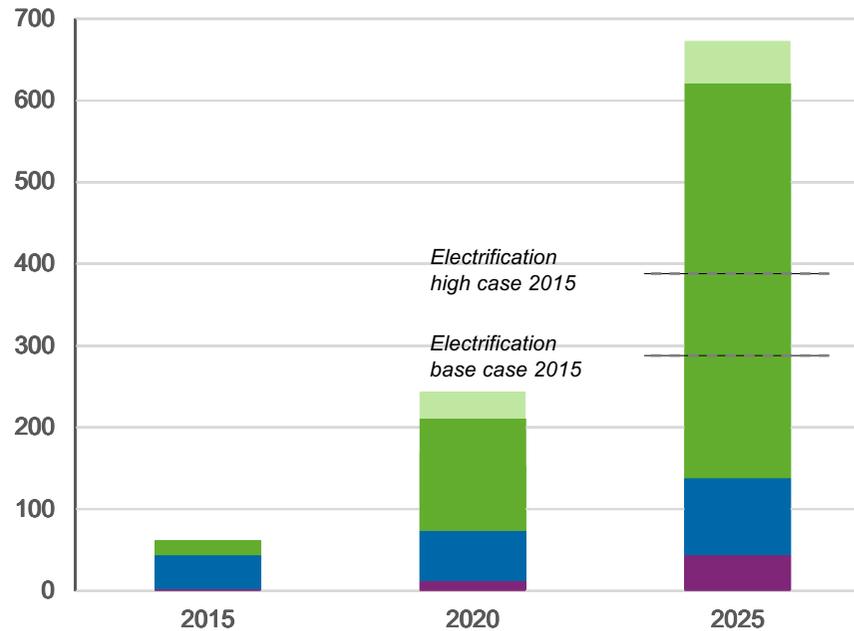
**Electrification**  
Regulatory driver



**Portables**  
Societal driver



**Energy Storage System**  
Regulatory driver



## RECHARGEABLE BATTERY MARKET (GWH)

- Heavy Duty Vehicles
- Electrification Current Scenario
- Portables
- ESS

Source: Avicenne, Navigant, Roland Berger, AABC, IHS, Gartner, SNR, CRU, Roskill

# Agenda

Business profile

**Accelerated growth in Electrification**

Success factors

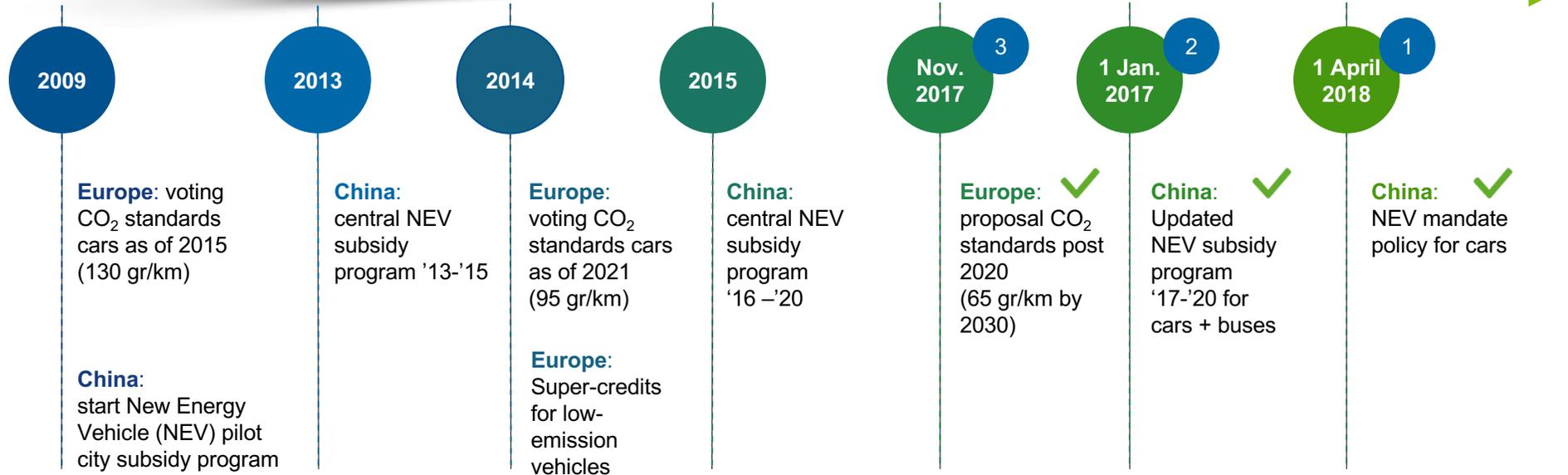
Key takeaways



# Intensified regulatory push

## Electrification triggered by legislation

Initiatives not yet known at previous CMD in Sept. 2015 ✓



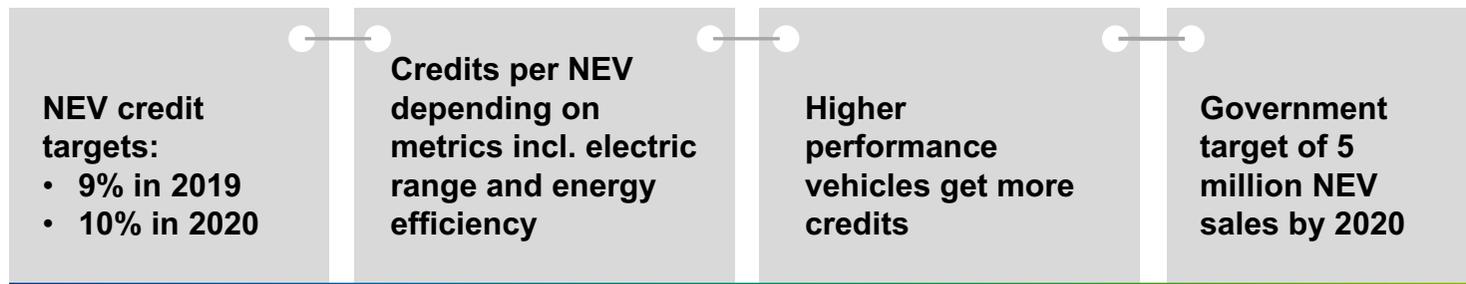
✓ **Europe (national level):** Several countries setting EV adoption targets / announcements of EV subsidies, tax breaks or special driving privileges

# Intensified regulatory push in China

## New Energy Vehicle mandate policy for cars

A milestone policy in China, the world's largest passenger car market - since April 1, 2018

### NEV CREDIT TARGETS



**China expected to account for over 40% of future xEV demand**

# Intensified regulatory push in China

## Updated NEV Subsidy Program

- Updated subsidy program for NEV cars and buses, valid through 2020
- Decrease in the per vehicle subsidy; subsidies attributed in **function of battery size and capabilities**



### NEV CARS

Higher focus on advanced technologies

Two new requirements: battery energy density and energy consumption



### E-BUSES

Minimum range increased to 200 km

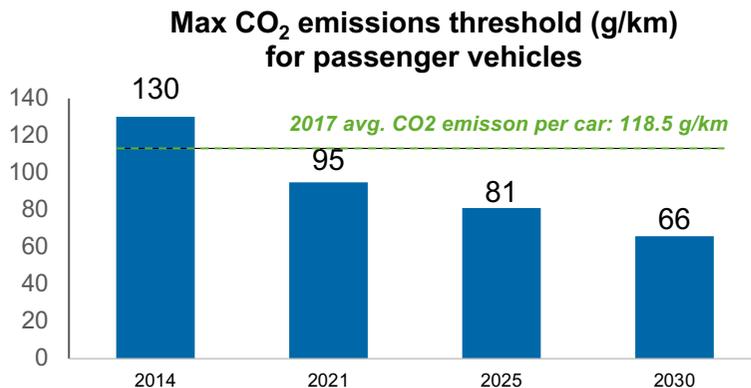
Additional requirements: battery mass ratio, charging speed and battery energy density

**Significant impact on cathode material chemistry: shift from LFP to NMC**

# Intensified regulatory push in Europe

## CO<sub>2</sub> Directive and low emission credits

### CO<sub>2</sub> EUROPE



Source: European Environment Agency

### SUPER CREDITS FOR LOW EMISSION CARS – accruing as of 2019

Increased weight for vehicles < 50 gr CO<sub>2</sub>/km

Low emission cars count double until 2023

Europe expected to account for up to 30% of future xEV demand

# Legislation triggered electrification

## And car OEMs embrace electrification

“ BMW Group announces next step in electrification strategy

25/07/2017

“ Volkswagen Group to expand production of electric vehicles worldwide on a massive scale

13/03/2018

“ Hyundai Motor Group Reveals Next-Generation Powertrain Strategy

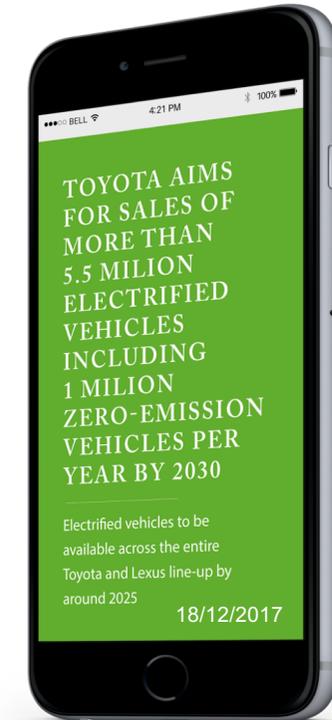
28/10/2017

“ VOLVO CARS TO GO ALL ELECTRIC

05/07/2017

“ GM Outlines All-Electric Path to Zero Emissions

02/10/2017



CAR OEMS' PRESS RELEASES

# Car OEMs roll-out their e-mobility strategies ...with an emphasis on flexibility

“ There’s going to be a co-existence between combustion engines and electrified drive systems over the next 10 to 20 years, so against this background **we should all be patient and relaxed and leave the decision to our customers, they should decide which concept they prefer.**

---

**Herbert Diess,**  
VOLKSWAGEN, CEO

“ We all know electrification is coming, but no one was aware how quickly it will arrive. Another challenge is that we don’t know when, where, or what customers will buy in the future. **To meet this challenge, we have decided to launch future products on a flexible architecture.**

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**Hanno Kirner,**  
JAGUAR LAND ROVER, EXECUTIVE  
DIRECTOR CORPORATE AND STRATEGY



COMMENTS  
FROM THE PRESS

**Major OEMs are massively increasing their offerings  
and this for a wide range of electrified vehicles**

# Agenda

Business profile

Accelerated growth in Electrification

**Success factors**

Key takeaways



# It takes a lot to play in the automotive league

## Car OEMs need :

### High quality cathode materials

- ... **custom made** for **different types** of xEVs
  - ... in **massive volumes**
  - ... at the highest **speed and flexibility**
  - ... at a **competitive price**
  - ...without any **sustainability image risk**.
- excellent product quality on 20+ specs
  - wide spectrum of cathode material technologies
  - industrial capabilities
  - ability to scale up fast
  - cost-efficient processes
  - ethically sourced materials

**It takes product technology,  
process technology and supply**

# Product, process and supply

## Key success factors

### 3 Supply



Raw materials

- Feed flexibility
- Battery recycling

### 1 Product Technology



Lab scale

Wide spectrum of cathode material technologies

### 2 Process Technology



Pilot scale

- Ability to scale up fast
- Cost-efficient processes
- Industrial capabilities



Industrial scale

Best in class product quality on 20+ specs:  
continuous fine-tuning at lab, pilot and industrial scale



Product  
technology

# Long wish list of users' requirements



## Cell type:

- hard case prismatic
- cylindrical
- pouch

## Electrode

- Wound
- Zigzagged
- Stacked

## Solvent:

- NMP
- water
- none

## Size:

- 4-10-40-150Ah



# Long wish list of users' requirements



## Safety approach:

- cell
- system

## Strategy:

- compliance
- embrace

## Range:

- long
- compliance focused

## Price

- premium
- mainstream

## Warranty

- cooling
- voltage adjustment



Product  
technology

# Long wish list of users' requirements



## CO<sub>2</sub> emission:

- Technology influence
- Public transport promoting



Product  
technology

# Long wish list of users' requirements



## Purchase motivators:

- TCO
- environmental
- driving performance
- range needs

## Car size:

- LDV
- HD
- e-bus



# Long wish list of users' requirements

<b>Cell maker</b>	<ul style="list-style-type: none"><li>• Cell type</li><li>• Electrode</li><li>• Solvent</li><li>• Size</li></ul>
<b>OEM</b>	<ul style="list-style-type: none"><li>• Safety approach</li><li>• Strategy</li><li>• Range</li><li>• Price</li><li>• Warranty</li></ul>
<b>Regulator</b>	<ul style="list-style-type: none"><li>• CO<sub>2</sub> emission</li><li>• Technology influence</li></ul>
<b>Customers</b>	<ul style="list-style-type: none"><li>• Public transport</li><li>• TCO</li><li>• Driving pleasure</li></ul>



Product  
technology

# Long wish list of users' requirements

## Defines key cell performance specs



Cell  
performance  
specs

- Safety
- Capacity
- Warranty
- Power
- Cost
- Cycleability



# Cathode material specs to fulfil cell performance specs



## Cathode material product specs

- Particle size
- Morphology
- Composition
- Purity
- Packing density
- Porosity
- Consistency
- and more



## Cathode material performance specs

- Capacity
- Power (charge/discharge)
- Cycle life
- Safety
- Charge efficiency
- and more

**Tailoring cathode material characteristics to the cell specs requires:**

Fundamental chemistry know-how to design the right product composition during lab phase

Ability to further enhance the product designs during 12-24 month qualification cycles in pilot phase



Product  
technology

# There is no such thing as one xEV



**BEV**  
long range

Low  
nickel NMC



High Ni  
chemistries





Product technology

# There is no such thing as one xEV



Low nickel NMC



High Ni chemistries

Safety



Driving Range



Durability/warranty



Cost



Power



BEV mid range

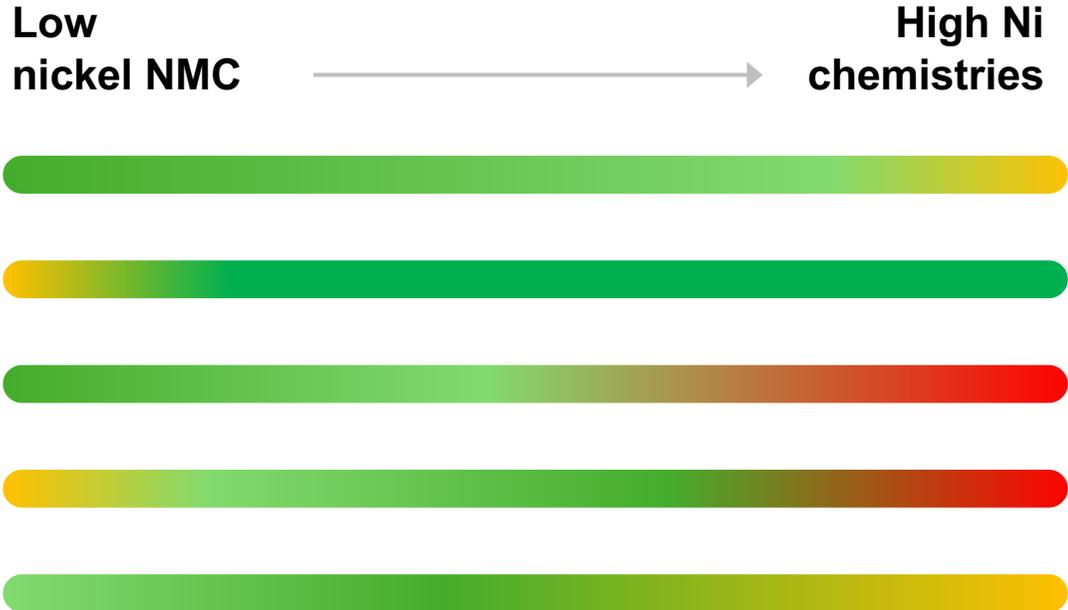


Product technology

# There is no such thing as one xEV



pHEV



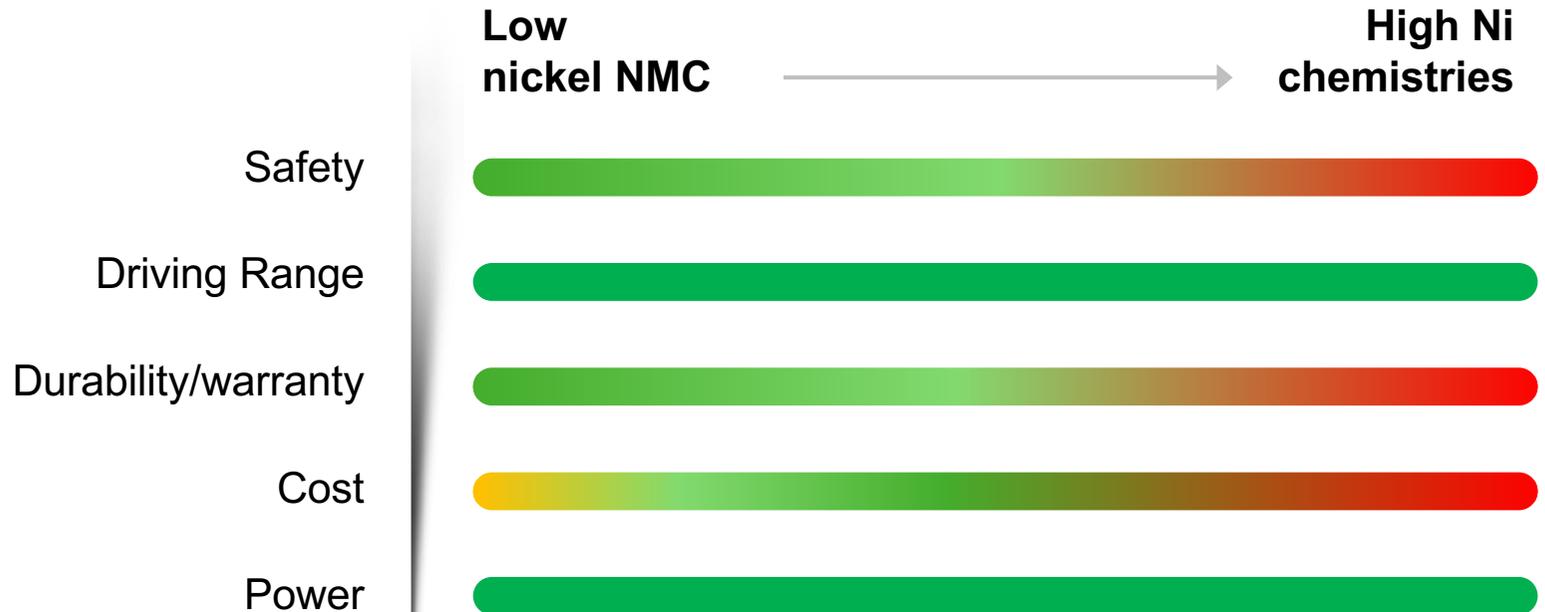


Product  
technology



E-bus

# There is no such thing as one xEV





Product technology

# And not one solution will fit all



Low nickel NMC



High Ni chemistries

BEV Long range



BEV Mid range



pHEV



E-Bus



Other (Indust.)



Transportation

Wide spectrum of cathode materials is and will be needed

With excellent product quality on 20+ specs

# Process technology as enabler for fast growth and cost efficiency

## FAST GROWTH

- Efficient from pilot to industrial scale
- Excellent product quality at large industrial volumes
- Capability to respond to market swings
- Production lines forward and backward compatible

## COST EFFICIENT

- Controlled capital intensity
- High throughput rate
- Maximize first pass yield
- Operational expenditures

### Umicore

- Industrial capabilities
- Ability to scale up fast
- Cost-efficient and lean processes
- Excellent product quality on 20+ specs

# Recent expansions deploying Umicore's innovative proprietary process technology

## Expansions on track:

- Sales projected to reach **100,000 t in 2019**
- Total capacity of at least **175,000 t in 2021** (full spectrum NMC grades)

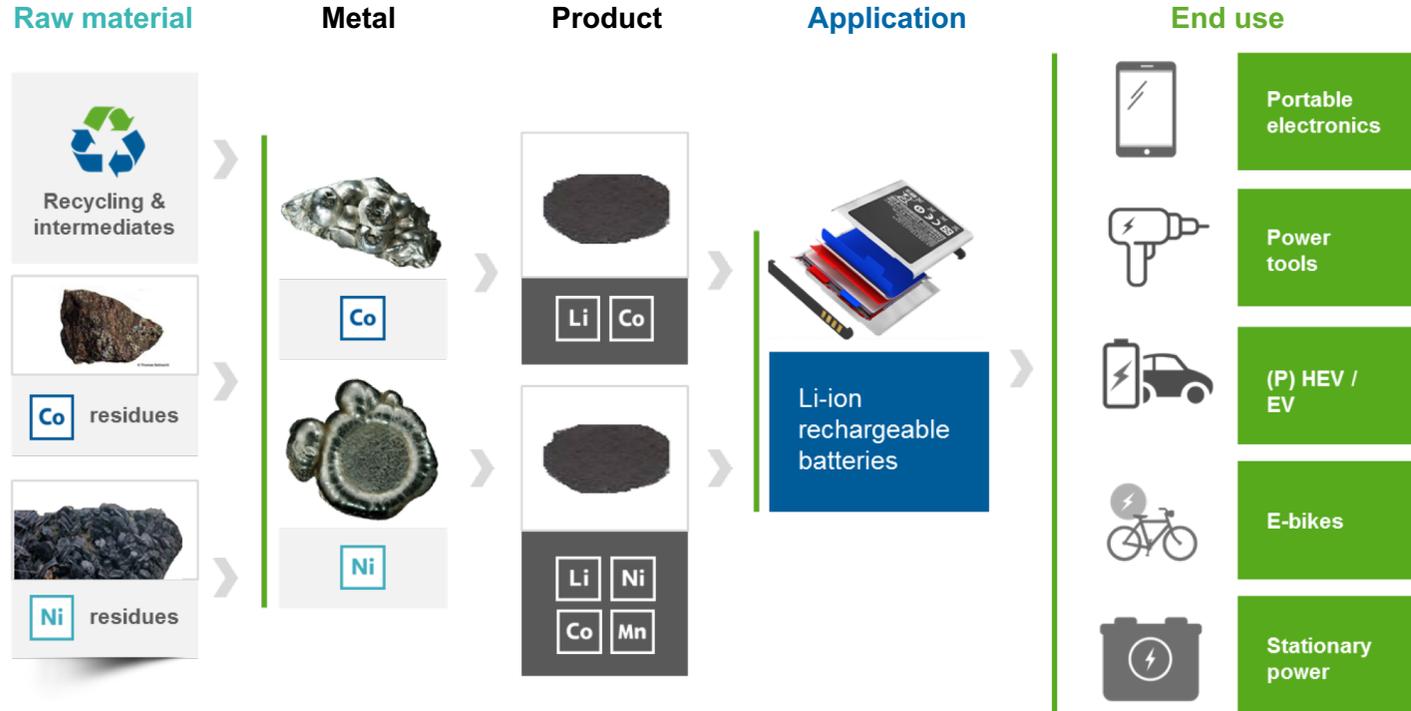
## Progress:

- **Korea:** first and most advanced project
- **China:** project on existing site is on track with a planned commissioning wave starting in Q4
- **Europe:**
  - Process Competence Center in Belgium as of end 2019
  - New site in Nysa (Poland) expected to be operational as of end 2020



# Access to raw materials

## Unique integration in the value chain



> Flexibility in supply feed, high speed to market and responsiveness to customer needs

# Access to raw materials

## Battery recycling as critical additional source of supply



- Urban mining indispensable for global electrification of transportation
- Proven industrial capabilities for all types and formats of Li-ion batteries
- Patented recycling technology
- High recovery rates for lithium, cobalt, nickel and copper
- Highest environmental standards



**Flexibility in supply feed, high speed to market and responsiveness to customer needs**

# Increasing the gap



**Further extend technology and market leadership** in xEV through strong focus on innovation and accelerated capacity additions

**Cost leadership** through economies of scale, process development, competitive sourcing and operational excellence

**Strong ties along the value chain** with suppliers, cell makers, OEM's allowing a real, sustainable closed-loop model

# Agenda

Business profile

Accelerated growth in Electrification

Success factors

**Key takeaways**



# Key takeaways

Increasing electrification drives massive market demand



Clear trend of product customization



Umicore uniquely positioned to capture significant growth in this segment:



- Full spectrum of highest quality cathode materials
- Process technology and ability to scale up fast
- Innovation pipeline spanning the next 20 years
- Integrated supply chain and battery recycling

umicore<sup>®</sup>

materials for a better life