



# BATCircle highlights

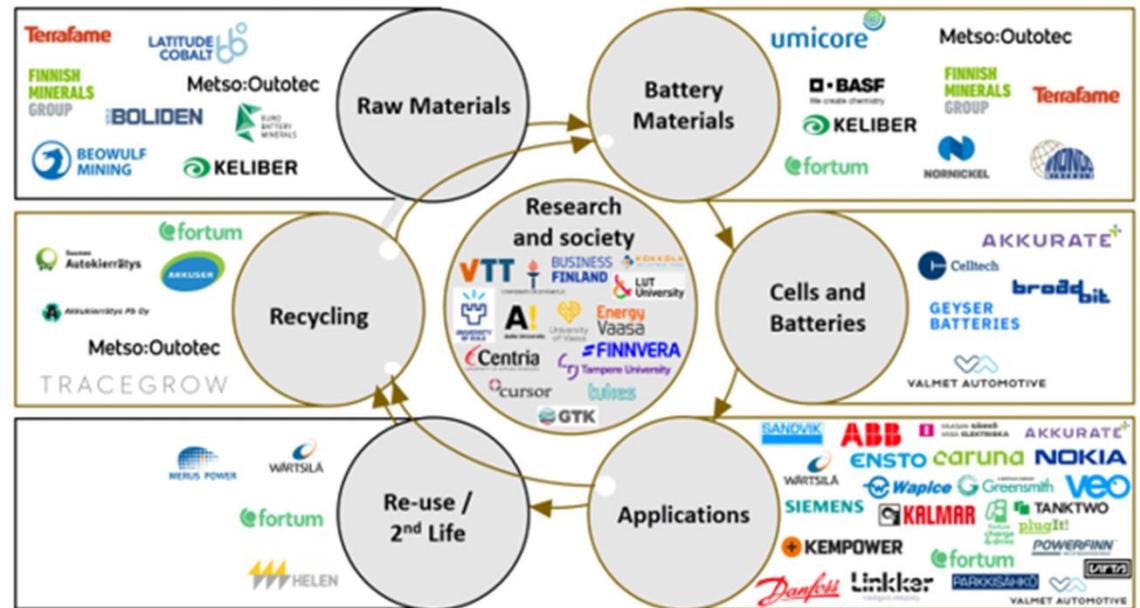
## Where did we start and where did we get to

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Technology manager – Battery chemicals  
Metso Outotec

**Metso:Outotec**

# Content

- Where did we start
- How was the journey
- Where are we going next



Key players of the Finnish battery value chain.  
Source: Finnish national battery strategy

# Where did we start

- BATTobe kick-start of BATCircle in April 2018
  - Wide industry participation, but emphasis on raw materials, advanced materials and recycling
- Plenty of business bubbling under, that fastly progressed to public announcements of investments
  - Terrafame, Nornickel, BASF, Fortum...
- European activity increasing along our efforts, business investments, politics, R&D
  - Our consortium presented in EBA on 25.4.2018

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Source: BATTobe slides early 2018

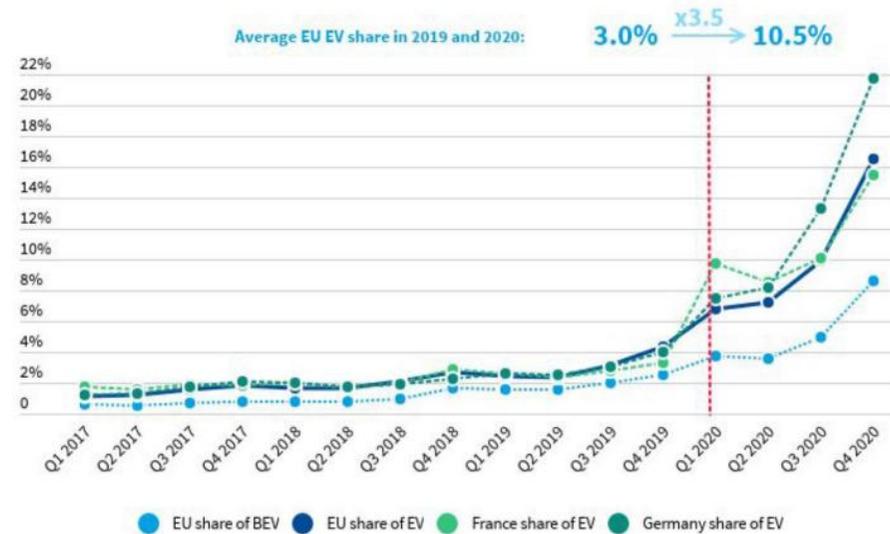


# Where did we start

- Technically and commercially many things were less clear than today, like
  - General understanding of batteries & the related value chain with its flexible details
    - Quite much less of us drove with an electric drive
  - Role of raw materials
  - One of the key themes battery recycling
    - For starters, where to get material for testing in our BATCircle project
    - When can we expect the business to take development over?
    - Requirements for recycling and desired product outputs being defined – is it only nickel and cobalt that pay off?

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## Europe EV sales actual



Source: ACEA (2021) Quarterly AFV registrations

Slide source: Bo Normark, InnoEnergy

# How was the journey



# How was the journey

- BATCircle set-up the pace for battery raw material and recycling activities in Finland and Europe
- Significant activity on all core areas of the BATCircle project, which is seen in increased business along the value chain
- Building new talents and capabilities – also along the “old Foxes”
- Strong delivery of the key BATCircle messages to our European communities, e.g.
  - European Battery Alliance
  - Batteries Europe
  - Batteries Europe Partnership (BEPA)
  - ERMA
- Important input to Finnish national battery strategy launched on 26.1.2021

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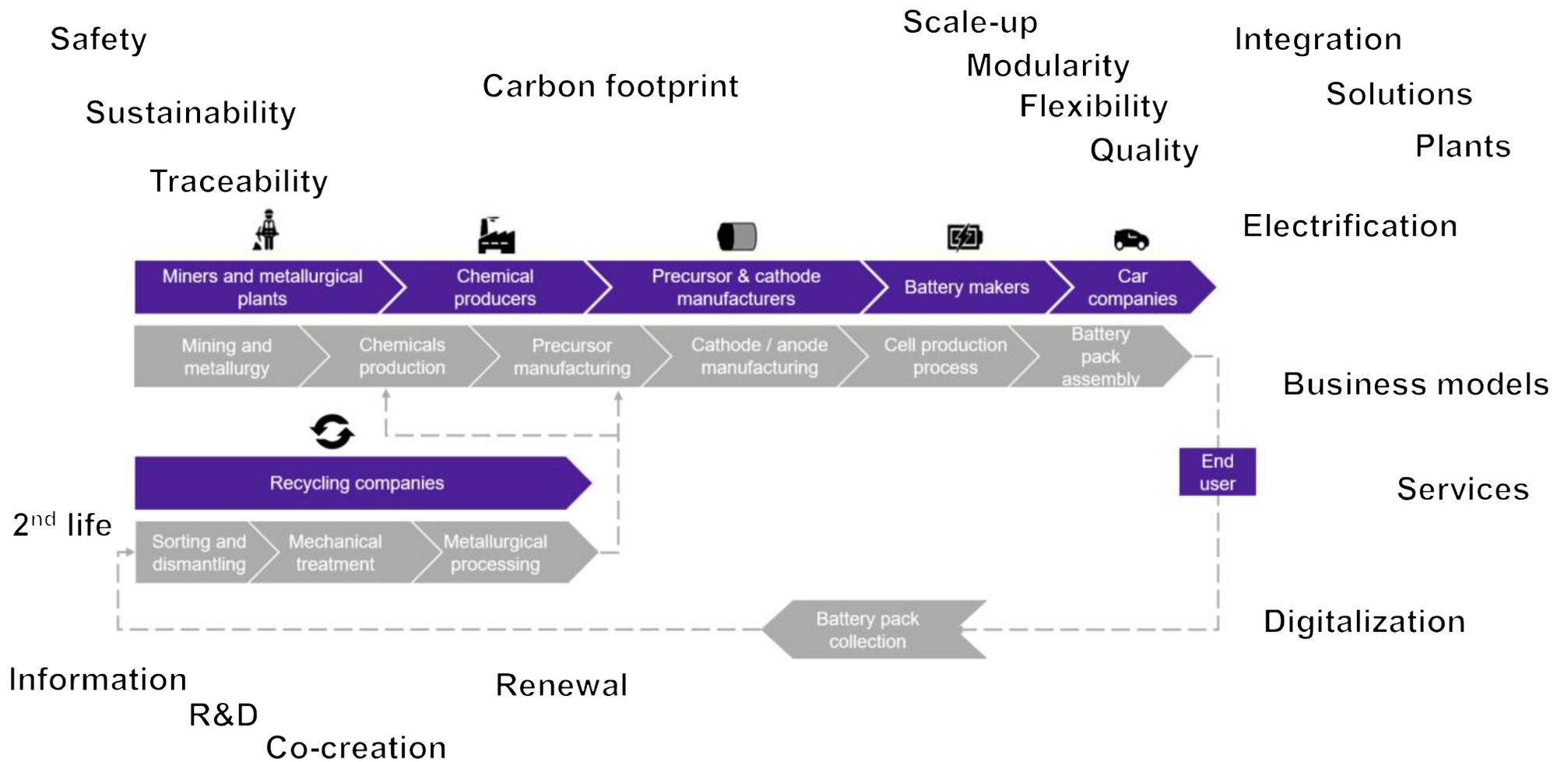
**Confirmed Working Group Chairs and Co-Chairs for first year of operation** **BATTERIES EUROPE**  
EUROPEAN TECHNOLOGY

Thematic Working Groups	WG1 New & Emerging Battery Technologies	WG2 Raw Materials and Recycling	WG3 Advanced Materials	WG 4 Manufacturing and Cell Design	WG5 Application and Integration-Mobile	WG6 Application and Integration-Stationary
Chair	Kristina Edström Uppsala University	Ilkka Kojo Outotec	Fabrice Stassin Umicore	Oscar M. Crespo CIDETEC	Simon Perraud CEA	Luigi Lanuzza ENEL
Sherpa	Ivana Hasa, KIT	Mari Lundström, Aalto university	Marcel Meeus, EMIRI	Arno Kwade, TU Braunschweig	Lucie Beaumel EGVIA	Rachele Nocero, ENEA
Co Chair	Stefano Passerini Helmholtz Institute	Olli Salmi EIT Raw Materials	Silvia Bodoardo Politecnico di Torino	Carlo Novarese, FAAM/Lithops	Franz Geyer BMW	Javier Olarte CIC Energigune
Co-Chair	Philippe Stevens EDF	Alain Vassart EBRA	Daniel Gloesener, Solvay	Michael Krausa KLIB	Josef Affenzeller AVL	Jesus Varela Sanz Iberdrola
	Research	Industry				



ETIP / Batteries Europe meetings in Espoo & Milan

# How was the journey: Creating value

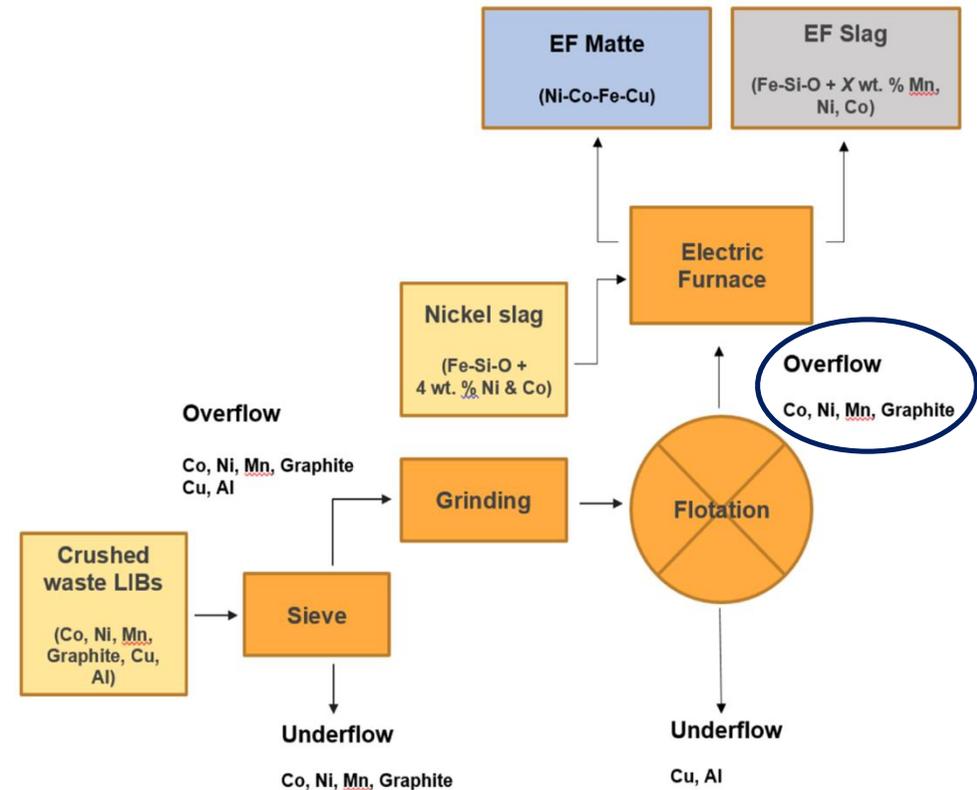




# WP2 - Value addition in metals production



- Key contributors **Aalto** and **GTK**
- Research on production of battery metals from different raw materials (identified in WP1) and improving the existing processes
- Supporting our Finnish world class refining industry
- One of the high-lights by Aalto in
  - Separation and flotation of Co-rich battery scrap
  - Co rich and "dirty" graphite fraction to electric furnace
  - Recovery of battery metals in nickel slag by reduction with graphite in nickel slag cleaning in electric furnace conditions



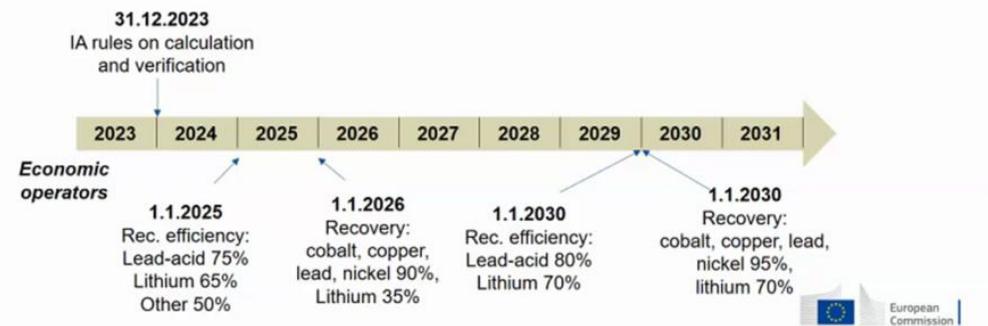
Ronja Ruismäki and Tommi Rinne, PhD students & Anna Dańczak, post-doc researcher, Profs. Serna and Jokilaakso

# WP3 - Battery recycling

## Development of key drivers for battery material recycling over our project time frame

- Demand for overall recycling rates will increase
- Specific elements will get own recycling targets  
→ challenge technology selection
- CO<sub>2</sub> footprint will play a key role, with whole value chain getting accounted for
- Recycled materials will have a value in new batteries - free willing or by regulation  
→ Focus on the form of recovered elements/products
- Raw material feed rates will grow patiently  
→ modular growth options for processing & integration to existing processing capacity needed for the shift period  
→ raw material flexibility needs to be an inherent property of process design, including also alternative raw material sources like off-spec from battery manufacturing

- Increased targets for waste **portable** batteries (except batteries for light means of transport)
- Current collection target: 45% of **portable** batteries
- **Industrial, automotive and EV batteries: no losses**, i.e. continuation of 100 % collection requirement
- **New reporting system**

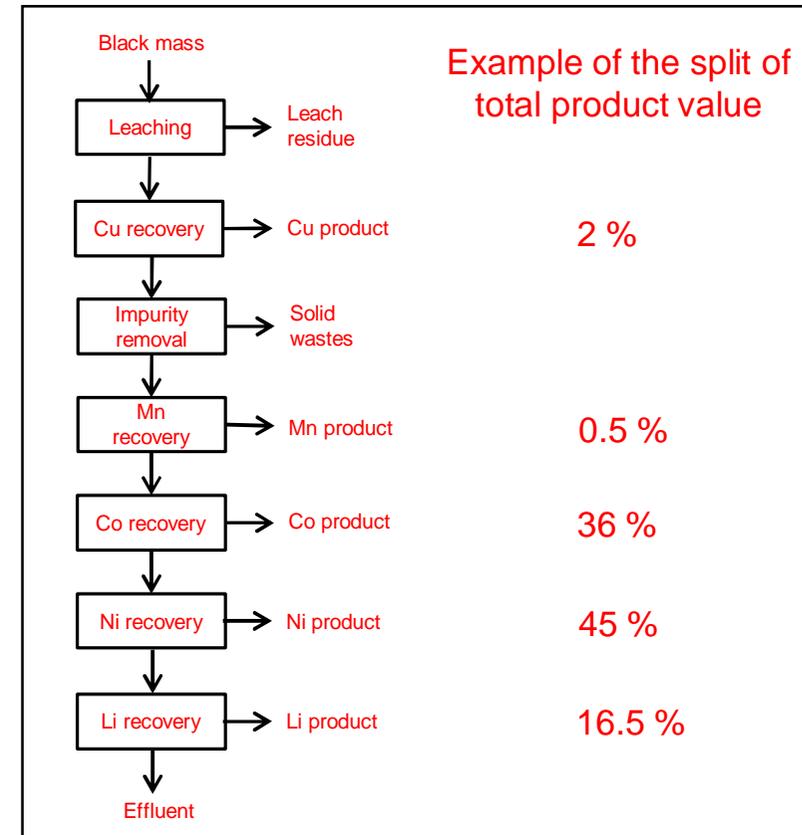


European battery regulation 12/2020

# WP3 - Battery recycling

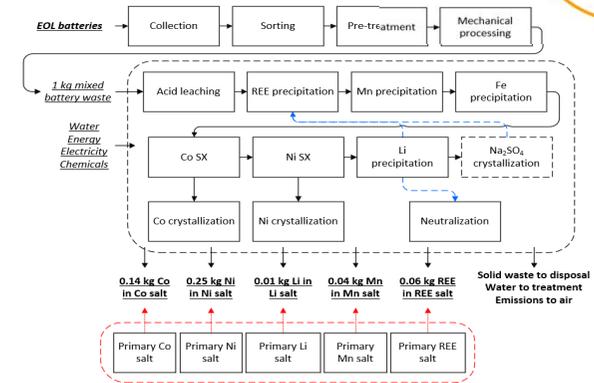
## Key drivers for battery recycling

- While the different targets and drivers affect the process selection, economy needed to justify the business
- This sets up the scene for developing processing methods that fulfill the targets for a sustainable industry
  - there is plenty of room for innovation, and more than one feasible outcome

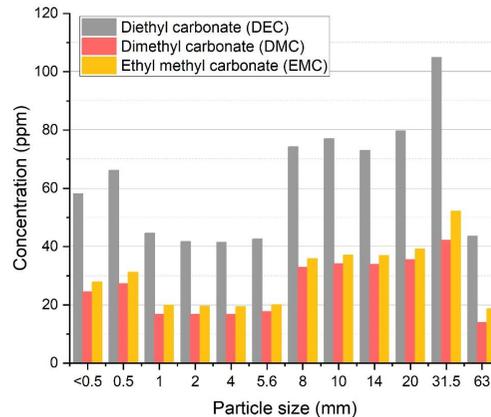


# WP3 Battery recycling

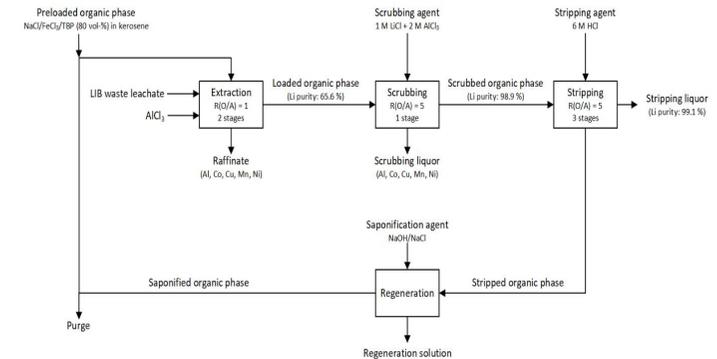
- Key contributors **LUT, Aalto and VTT**
- **Some highlights on carbon emissions, recovery in recycling and safety**
  - Aalto work on defining LCA for the combined NiMH and Li-ion battery recycling
    - The GHG emissions of the process were estimated to be 3.7 kg CO<sub>2</sub>-eq for 1 kg treated batteries - more than 30% lower than for virgin raw materials for new batteries
  - LUT working on direct lithium recovery
  - VTT work on characterization of recycled battery components during mechanical separation



Aalto: Technical boundary and process steps in the study



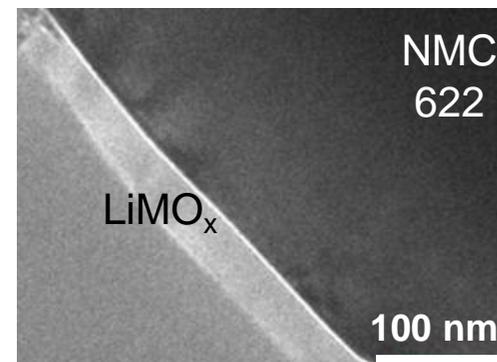
VTT: Carbonate emissions detected with FTIR from e-bike sample over a year after crushing.



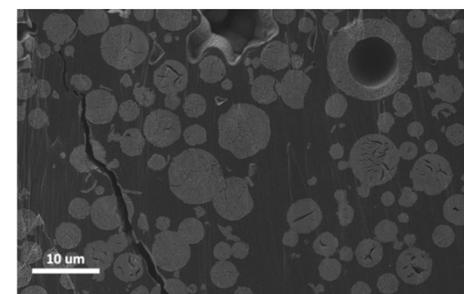
LUT: Direct lithium recovery from Li-ion battery waste leachate

# WP4 - Tailored precursors and active electrode materials

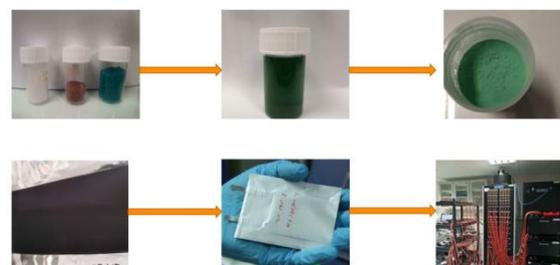
- Key contributors **UEF, Oulu, GTK and Aalto**
- Some highlights on precursors and CAM
  - Aalto investigating enhancement of energy storage capacity and cycle life on NMC 622 by coating with lithiated transition metal oxide
  - UEF investigating NMC 622 synthesis, with specialization in gas phase synthesis
  - Oulu investigating methods on co-precipitation of precursors for high-capacity cathodes along the use of secondary raw materials as starting material



Aalto: NMC 622 coating



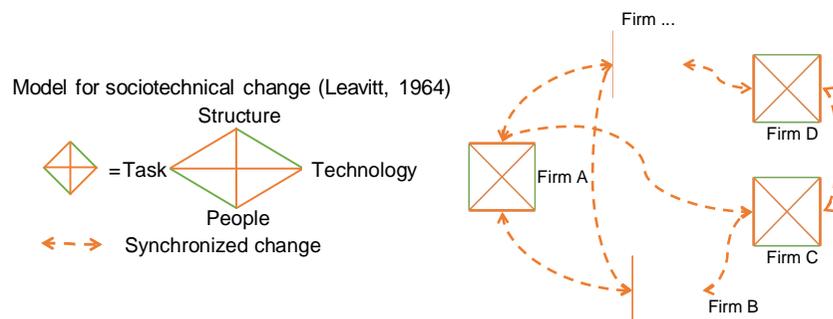
UEF: NMC 622 precursor material after Spray Drying (ion milled SEM)



Oulu: Use of secondary raw materials for cell manufacturing

# WP5 Business potential

- Key contribution: **Aalto**
- **More than 100 interviews and more than 10 research articles!**
- **Key findings:**
- **Business models describe how organizations function to achieve their goals** and are used to outline activities on two levels: focal firms and broader systems (e.g., markets, supply chains, ecosystems). While the business model is **often centered on the actions of a single organization**, the **growing interdependencies across all sectors are making it increasingly important consider the focal firm's role and interlinkages as a part of larger, encompassing system**.
- Firms operate for their own benefit. Since the **circular ecosystem for batteries relies on the interplay of numerous firms and other actors**, the competitive dynamics in the industry require reconsideration. When planning for the circular business models for the battery industry, specific importance should be given for **creating incentives for single firms to choose activities that serve the overall goals of the ecosystem**.
- The business model research should give specific emphasis on identifying means to **track individual actions and their impact on the broader ecosystem**. Future research should focus on new means to document and compensate actions that benefit the jointly set goals for the ecosystem. One potential avenue is the research on **distributed governance technologies**. **The industrial firms should take a constructive approach for developing new partnerships and models for sharing value**.



*"Multiple firms need to engage in synchronized changes of their existing technologies and practices (e.g., in temporal, cognitive, or locational aspects)."*  
(See: Gao, 2020)

# New talents, capabilities and scientific input



## BATCircle Publication list (Updated on 8.3.2020)

- 24 Published peer-reviewed publications, **27 submitted or to be submitted**
- 26 Published theses (3 D.Sc. Theses, 21 M.Sc. Theses, 5 B.Sc. Theses), **1 D.Sc. thesis to be defended**
- 4 Published reports, **2 forthcoming**
- 36 Conference presentations, **5 to be held**
- 6 Magazine articles

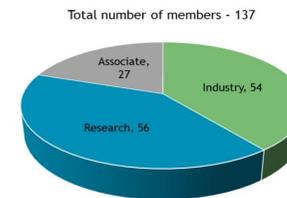
# Where are we going next

- BATCircle 2 consortium was built-up, and applications filed end of 2020
- Batteries Europe WG2 work continued in the lead of Mari Lundström – Thanks to BATCircle WP7!
  - Also increased activity of BATCircle members in other WG's
  - Horizon Europe is here → new focused R&D on the most urgent Battery value chain topics
- Batteries Europe Partnership, BEPA, established, with good share of participation of BATCircle participants
- Finnish national battery strategy getting implemented, polishing further the diamonds created in BATCircle

**Market and need will be there - hotter than ever and the BATCircle topics are expected to remain in focus!**

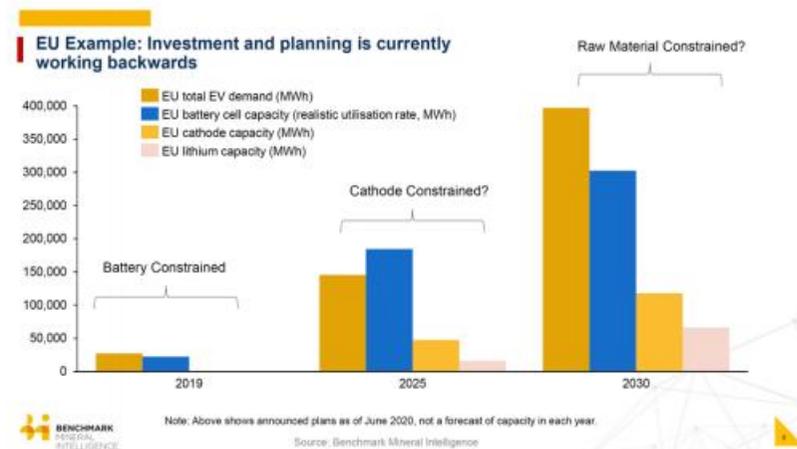
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## Distribution of BEPA members (Dec 2020)



Slide source: BEPA

## Where will the constraints be ?



Source: Bo Normark, InnoEnergy

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# Partner for positive change



[mogroup.com](http://mogroup.com)

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