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*Alliance for Batteries Technology, Training and Skills*

*2019-2023*

# ALBATTS Webinars - Round 3:

# Mobile Battery Applications

# &

# Job roles, Skills and Competencies Needed

Deliverable 5.9 Future Needs Definition for sub-sector IMBA_Release 3

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## Cover Page

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## Executive Summary

Two interviews and four webinars focusing on current and emerging **needs in job roles and skills** were organised by the ALBATTS project *Work Package 5 – Intelligence in the Mobile Battery applications* in the third and final series of events between October 2022 and January 2023.

The interview **"Future Battery Technologies, Job Roles, Skills & Knowledge"** with **Assoc. Prof. Ing. Tomáš Kazda, PhD** by Prof. Dr Maria Helena Braga, University of Porto (FEUP), was held on 26. 10. 2022 and provided the following key findings:

- Future battery technologies currently researched include **advanced lithium-ion, sodium-ion, lithium-sulphur, lithium-metal, solid state** and **structural batteries**
- The Czech Republic has a history of coal mining and relevant education and pieces of training available. As coal mining is being phased out, these courses can be switched, and the workers **re/up-skilled** to mining and processing raw materials for batteries since there are deposits of lithium, manganese, graphite and cobalt
- Some students **are worried** about taking courses on topics related to batteries – they do not know much about it, and they worry about the complexity, chemistry and so on
- The industry is looking for people with specific **deep knowledge**, but also for people with a **very wide knowledge** to communicate with different sectors and connect them together
- **Minimal training** for technical people shall include training on what the battery is, how it works, what is the working voltage, what safety issues are, how to handle the battery

The following job role needs were identified in the interview:

- Electrical engineering
- Chemical engineering

The interview **"Future Battery Technologies, Job Roles, Skills and Knowledge"** with **Prof. Dr Noshin Omar** by Prof. Dr Maria Helena Braga, University of Porto (FEUP), was held on 14. 11. 2022 and provided the following key findings:

- **Li-ion technology** will be improved by 2030, then slow transition (step by step) to another technology (Silicon-based anode and solid states)

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- Jump to **solid state** is not easy – different technology, different supplies… many needs in skills
- The biggest challenge when building a gigafactory is to ensure a **stable supply chain**
- **A recycling hub** needs to be in every region or country to lower the footprint from the transport of waste
- **Sodium** technology to be used for **stationary** applications and **low-performance mobility**
- **Mass production** of batteries to lower their costs
- There is a **big gap** in programmes in education **levels 5** to **7-8**
- The industry is **changing** very fast; regulations are **lagging behind. More industry - EU Commission** is needed
- Ranges up to **200 – 300 km** are suitable for **electric trucks**; for longer ranges, hydrogen might be more suitable, similar to maritime vessels

The following job roles and skills needs were identified in the interview:

- Chemical engineers
- Electrochemical engineers
- Cell designers
- Electrical engineers
- Process engineers
- Modelling
- Thermo-management

The webinar **"Electrification of the Aviation Sector & Future Qualifications Needed,"** organised by ALBATTS project member HE3DA, was held on 17. 1. 2023 and provided the following key findings:

- Electrification of aircraft (hybrid) allows for **new aeroplane concepts**, such as those with **vertical** take-off and landing
- Air taxis for a very **short distance** (up to 20 km) are not economically viable
- The battery capacity of around **80 kWh** or less (smaller than in most EVs) for a small passenger/cargo aeroplane

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- No special training for the pilot is needed. However, the **ground crew** must know the basics – not touching the **high-voltage** battery, etc.
- The **automotive industry** can be the source of some of the relevant skills. Getting skilled people from the automotive industry to the **aviation industry** is a big challenge
- Heavy hydrogen tanks complicate a broader use of **hydrogen** in aircraft

The following job roles and skills needs were identified in the webinar:

- Powertrain architect
- Battery designer
- Controller development

The webinar "**Electrification of Heavy-Duty Vehicles: What Skills and Competencies Will Be Needed?, "**organised by ALBATTS project member ACEA, was held on 29. 11. 2022 with the following key findings:

- Truck manufacturers are dedicated to the **decarbonisation of their fleets** using electric trucks, but also hydrogen and other alternatives
- OEMs have set internal decarbonisation targets, such as 2030 – 60 % of vehicles zero-emission vehicles, **2039 - 100 %**
- Heavy duty vehicles = daily usage = need to be **100 % sure** that it will work
- Heavy-duty batteries operate on higher voltage (above **500 V**). In the past, in passenger vehicles, the battery voltage was under 500 V, now they are starting to go **800 V**
- Charging speed varies from e. g. **medium-size 16 t** trucks that can charge **22 kW AC** overnight to **large 60 t** trucks able to charge up to **350 kW DC**
- Future outlook - **Megawatt charging** – charge up to **80 %** in **less than an hour**
- Charging infrastructure in the **depots** needs to be rolled out - need to have a stable **source of energy** – for the building and for charging trucks as well – **energy management** is vital
- Crucial - **safety** with electrification, battery knowledge, manipulations with the batteries
- Different kinds of **competence levels are needed - experts/specialists** in specific areas – but also many with **general knowledge**
- The essential skills for electrification of heavy-duty vehicles = **business** and **technical**



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- **Driving** an electric truck is way **easier** than driving a diesel truck; drivers are **satisfied**
- **The mass and safety** of the batteries are the main challenges. **Safety features** in trucks: monitoring, safety shutdown, electric protections
- Need to avoid breakdowns - **predictive maintenance** (**digital twin**)
- **Workshops/training** on EV components, hydrogen components, **building the infrastructure**…Drivers training, driving behaviour
- Driving a small 4.25 t eVan with a driving licence for a 3.5 t vehicle – **mandatory training** in Germany for 5 hours
- **Certification** to use and also move in an environment where **high voltage** is
- **Wireless charging** = many difficulties, such as the problem with the **positioning** of the vehicle (extremely critical) – difficult/costly application in highways for trucks. More considerable potential for **busses** that go the same way and have the same stops every day

Job roles needs identified in the webinar

- Electro-mechanical engineering (*comment of a participant in an ex-post survey*)
- Project leader

Training needs identified in the webinar

- Mandatory training for **drivers in Germany** taking 5 hours
- Training on **EV components**, infrastructure building
- Drivers training - **driving behaviour**
- Certification to use and also move in an environment with **high voltage**

The webinar **"Electrificaton of Inland Waterways & Future Qualifications Needed,"**organised by ALBATTS project member Corvus Energy, was held on 26. 1. 2023 and provided the following findings:

- The advantages of electrified inland waterway vessels include a reduction in **$CO_2$** and **$NO_x$** emissions and other pollutants, as well as **noise** reduction
- **Tens of electrified** ferries have already been in operation in Norway
- Land infrastructure requires **grid upgrade, battery bank, charging** tower - transmission (22 kV, 400 V, 590 V, 690 V), charging power (**1,750 kW)**
- Hybrid-electrical fishing vessels allow for fishing without noise

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- A fully electrified **container ship** can have a battery pack with a capacity of **6.7 MWh**
- Engineers on board have been improving their expertise in battery and hybrid operations - engineers get specific **training** and assistance from equipment suppliers in case of errors. **Fire protection** and **safety** are among the key topics, together with **temperature monitoring, thermal runaway protection**
- To be sustainable, a long battery life cycle is necessary - the life cycle of the ship is **much longer** than a truck, for example
- **Exchangeable battery packs** are one of the possible technological concepts - the challenge is in changing the batteries **quickly**

Job roles, skills and knowledge needs identified in the webinar

- IT, cyber-security, programming skills
- Hands-on engineering and servicing skills
- Impact/lifecycles/circularity assessments

Training needs identified in the webinar

- **Fire protection** and safety are among the key topics, together with **temperature monitoring, thermal runaway protection**
- **Education** for students shall include a combination of **different types** of fuel power (batteries, $H_2$, LNG, diesel, Solar panels…)

The webinar **"Safe Recycling & Second Use of Batteries: Skills and Competencies Needed,"** organised by ALBATTS project member ITC, was held on 27. 1. 2023 with the following key findings:

- **Recycling capacities** need to be expanded as the current recycling infrastructure capacities are unsuitable for the estimated volume of spent batteries.
- There is a severe shortage of **courses and training** in battery recyclating, such as the training on **norms & standards**.

Job roles, skills and knowledge needs

- Automated dismantling
- SoH estimation methods
- Design for recycling & reuse
- New generation BMS's & EMS's

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- Battery diagnostics and repair
- State of Health estimation
- Battery dismantling
- New system design/assembly
- Machine Learning Architect
- Data Engineer/Manager/Leader/Scientist
- Analyst
- Lab testing, design, and supervision of data quality
- Fast, cheap, and accurate SoH, SoC estimation from the field, historical, and lab data
- Anomaly detection and batteries security
- Developing AI and physics-based models
- Capturing non-linearities
- Optimising the parameters, model validation, and testing
- Analysing, cleaning, exploring and getting insight from data and designing impactful KPIs
- Design resilient and scalable architecture and infrastructure
- Developing Data Pipelines
- Cybersecurity and data privacy
- Frontend-Development
- Backend-Development
- Software-Architects
- DevOps
- Battery pack disassembly

*Information about all the events and **video streams** can be found on the website of the ALBATTS project (Events section).*

*The key findings from the interviews and the webinars will be **further elaborated** in the upcoming Work Package 3 report due in May 2023.*



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## List of Abbreviations

| | |
|---|---|
| ABEE | Avesta Battery and Energy Engineering |
| AC | Alternating Current |
| BESS | Battery Energy Storage System |
| BMS | Battery Management System |
| BUT | Brno University of Technology |
| CEO | Chief Executive Officer |
| $CO_2$ | Carbon Dioxide |
| CSMS | Czechoslovak Microscopic Society |
| DC | Direct Current |
| EMS | Energy Management System |
| EU | European Union |
| EV | Electric Vehicle |
| GW | Giga Watt |
| HR | Human Resources |
| HSC | High-Speed Craft Vessels |
| IT | Information Technology |
| LFP | Lithium Iron Phosphate |
| Li-ion | Lithium-ion |
| Li-S | Lithium-Sulphur |
| LNG | Liquid Natural Gass |
| LTO | Lithium Titanium Oxide |
| Ni-Cd | Nickel-Cadmium |
| Ni-Zn | Nickel-Zinc |
| NMC | Nickel Mangan Cobalt Oxide |
| NTO | Natrium Titanium Oxide |
| OEM | Original Equipment Manufacturer |
| SOC | State of Charge |
| SOH | State of Health |
| VTOL | Vertical Take-Off and Landing |

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# 1 Introduction

The organisation of workshops is specified as Task 5.4 Future Needs Definition in the ALBATTS project application. Within this task, altogether, three reports have been produced:

- The **first report** (Delivery 5.3 or, shortly D5.3 in the project application) was published in February 2021, focusing on job roles and skills relevant to battery applications in the automotive and maritime sectors.
- The **second report** (D5.6) report focused servicing of EVs, the impact of the new EU battery regulation and autonomous operation and virtual reality in maritime applications
- This **third** report (D5.9)

The workshop activities **build on previous tasks** carried out by the ALBATTS project, extend the sectoral intelligence gathered within the project, and serve as an input for deliverables of the ALBATTS project Work package 3 - Sectoral intelligence, where the findings will be elaborated in more detail, and also for **Work package 6 – Training and Education**.

The latter-mentioned work package will use data from the report to address its primary task: propose curricula updates, introduce training, etc., to reflect the future skills needs relevant to the emerging battery eco-system.

Due to the synergies, the **organisation** was coordinated in joint meetings of relevant partners of Work Package 5 (WP5 – Intelligence in Mobile Battery Applications, IMBA) and Work Package 4 (WP4 – Intelligence in Stationary and Industrial Battery Applications, ISIBA). These regular meetings led by WP4 project partner EFACEC dealt with overall coordination and ensured a consistent approach to the organisation of the workshops.

To deal with daily issues and specifics of the individual webinars, several working meetings were organised and led by **partners responsible** for the individual workshops: **FEUP, ACEA, HE3DA, ACEA, Corvus Energy** and **ITC**. In addition, rehearsal meetings were led by project partner **EUPPY**.

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## 2 Future Battery Technologies – Interview with Prof. Tomáš Kazda

*Agenda*


**Figure 1: Agenda of the interview**

*Purpose of the interview*

The purpose of this interview is to provide a discussion about the current and the new trends in battery technologies and their chance to flourish in the automotive industry and grid.

*Why was the topic chosen?*

To explore the trends in battery-relevant Research & Development areas and relevant job roles, skills and knowledge needs.



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*Registrations*

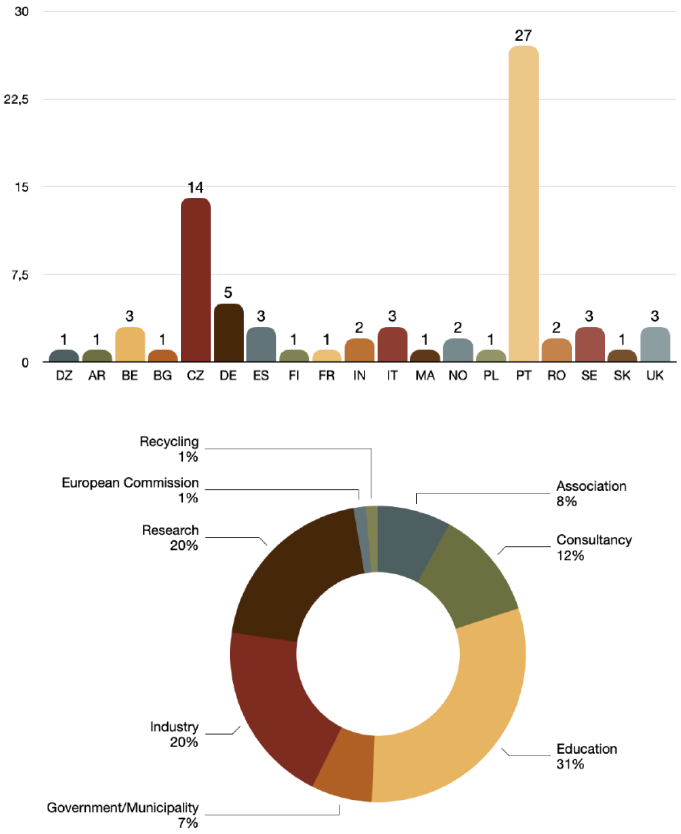


**Figure 2: Number of registrations and their distribution by sector**

*Participation*

The number of participants via the Webex online platform was **44**; other viewers followed the event's live stream on Facebook. Others have been accessing the recording on the ALBATTS website. The stream remains available there for further viewers.

*The Interviewer*

**Prof. Dr Maria Helena Braga,** University of Porto

*The Interviewee*

**Assoc. Prof. Ing. Tomáš Kazda, PhD**

- Works as an associate professor at the Department of Electrical and Electronic Technology, Brno University of Technology. He finished his PhD in 2015 in the field of electrodes for lithium-ion accumulators. In 2014, he received the FEI and CSMS (Czechoslovak Microscopic Society) Grant for Young Scientists.



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- He is an investigator or co-investigator of several Czech and foreign battery projects. He participated in several internships abroad (Vienna – Austria, Padova – Italy, Barcelona – Spain, La Plata – Argentina, Braga - Portugal). He has gained knowledge and experience in electrochemical measurements, synthesis of electrode materials for positive electrodes of Li-Ion batteries, and post-lithium systems.
- It also works with the industry in the application of Li-ion batteries and advanced battery systems, including their recycling. Since 2017 he has been a member of the Committee for Sustainable Energy and Sustainable Transport of the Government Council of the Czech Republic. Since 2019 is a Vice-Chairman of the international conference Advanced Batteries, Accumulators and Fuel Cells. Since 2022 is a Chairman of the Czech Battery Cluster

## The interview

*Electrical engineering background – you work on the individual parts of batteries (Cells) – that is not common for batteries – most often, it is **chemical engineering**…What is your fascination with this battery field?*

- Tomas Kazda is from the faculty of **electrical engineering** but from the department of electrotechnology – a solid connection to the materials
- Department has a long history in the research of batteries (since 1966)
    - Lead-acid, Ni-Cd, Ni-Zn
    - Research of Li-ions since 2008-2009
    - Strong group researching fuel cells.
- Bachelor thesis on low-temperature fuel cells – master's thesis about corrosion – PhD: Cathode materials for Li-ion
    - We are not chemists – not such a deep knowledge of the materials and reactions, but a strong view of the practical usage of batteries

*What is your vision for the future of batteries – what can come after Li-ions? Materials, architecture, modules, recycling…*

- One conference in Buenos Aires – presentation of prof Auerbach – "After the Li-ion batteries will be Li-ion batteries, then Li-ion batteries (like **advanced Li-ion**) and then comes something new."
    - Partially agree – right now, we start the application on a broad scale; in 10 years, a major type of batteries, and after that, maybe something new
- New technologies – probably **Sodium-ion** low-temperature batteries (interesting, close to the Li-ion, in EU few start-ups…)
    - Big producers (CATL) – they will try to start the commercial production of Na-ion in 2023-2024

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    - **Li-S** – very interesting in high energy density, big sources of sulphur, the magic of sulphur chemistry
        - It can be used with sodium as well
    - **Solid-state** Li-ion batteries – really interesting, pretty significant progress in this field, but on the market may be close to 2030 because there are still many problems
    - Solid-state is not only changing something from a liquid to a solid, but there is a lot to do to make it work
        - It can work in lab cells, but it will be tough to scale it up to GW production
- The challenge of the **integration** of new technologies **into current factories**
    - If the new technology brings up, for example, more capacity (+5-10 %), the company will not do it because the cell must be built differently, and it means maybe hundreds of millions of dollars on investment to make such a small improvement in capacity
    - This problem occurs with nearly everything – humanity does not like big changes…
- Additional question – do you see Li-S without lithium metal?
    - With lithium metal, you can have full capacity
    - In Li-S, you have to use **Li metal** or highly **lithiated silicon** because, on the cathode side, there is enormous capacity, so on the anode, you have also to use something with high capacity to have the balance
    - The problem with Li-S is not only with sulphur on the cathode side but also on the anode – a very complex problem

*In the Czech Republic, you are considering building a Giga factory (signed pre-agreement). What advice would you give to your politicians? What are the critical points about this? A lot of new jobs in the EU; how to provide these jobs? Do you have something about this?*

- Map of gigafactory projects in EU – you can see that in the Czech Republic is still nothing…
- Last week the government signed up pre-agreement that they offered Volkswagen the place for the gigafactory. Now we have to wait if Volkswagen decides to build the gigafactory there because they also think of building it in Poland or Hungary
- If it is in the Czech Republic, we will have much work to do – mainly **reskilling and upskilling** the people for these new positions
- ČEZ (the leading electricity distributor and owner of nuclear power plants in the Czech Republic) – also looking for a gigafactory. Already have the place for it – brownfield after brown coal powerplant.
    - In the Czech republic's long history in coal mining – mines will be closed soon, so it is a huge opportunity for those people to upskill in new positions in gigafactory
    - Strong car industry (Skoda, Toyota, Hyundai), truck producers…all of those have to be converted to the electric – opportunity to start working on the field of batteries


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- In the Czech republic pretty big amount of raw materials (lithium, manganese and also some graphite and cobalt)
- The Czech Republic is in a good situation but has to use it

*What is your vision for reskilling people, from coal mining to battery production, for example?*

- Long-term project – not able to reskill the people in one year
- New courses at the universities must be set up (focus on electromobility and batteries)
- In Hungary, they have national plans for reskilling the people…in the Czech Republic, we do not have it yet
    - However, in Hungary, there are already many battery manufacturers (Samsung, CATL…)
- Right now, we are working on **master courses in the field of electromobility**, part of which will be **battery research**
- As mentioned, we have a long history in coal mining – some universities also focus on coal mining. Mining is still mining, so they can **convert from coal mining to raw materials mining**. The basic principle is the same, and they only need to study something new in addition to **mining lithium** or **manganese**
    - Lithium is usually in the brines, petalite or spodumene form. In the Czech Republic, we have a special type of mineral: Lithium-Tin (at Cínovec)
        - Is it easier to mine or refine? – It is different. You have to use modified technology for the extraction. University of Chemical Technology in Prague developed its extraction technology. Right now, they are doing pilot testing to prove the cost efficiency of this technology

*Is your vision of batteries coming from the position of associated Professor at the university or from the position of chairman in the Czech battery cluster?*

- The cluster was set up this year after two years of discussion with universities and companies
- So the main point of view comes from the university, but in the last years, after discussions with companies, it also comes from them
- We asked the companies and universities on which part of the battery value chain they work – they realised that on every part of the value chain, there is some university and some company (quite good) – they can be connected together
    - In the Czech Republic, the cooperation between universities and companies is **not so good** (it is getting better)

*Experience outside Europe. If you go to the lithium triangle (Atacama desert), they already produce lithium from brine (lakes, problems with water). How do they bring value to lithium? It is not only about mining but about the **added value of lithium**. What is your knowledge about it, your feelings?*

- I have been to Argentina several times (during PhD and after that). Quite a good relationship with Argentina (visiting Professor in BUT right now)
- Argentina has significant sources of lithium (mainly in brines). About 25 companies produce lithium from brines – some also have pilot plants of Li-ion batteries.

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- Problems with financing. You need a lot of money and support from the government

## Questions from the chat

*Hello, everyone. First of all, thank you, Professor Tomáš, for your interview. In terms of **cathode materials**, with what type of materials did you work? Did you prepare the materials yourself, or did you use the commercial alternatives? Thank you so much.*

- Both. We work in different fields (**Li-ion, Li-S, Na-ion**)
  - For Li-ion, we synthesised $LiFePO_4$ (Lithium-iron phosphate or LFP for short), lithium-cobalt oxide and HV spinels for the cathode sides. For the anode sides, we prepared lithium titanates (LTO).
  - Na-ion also titanates for anodes, bud sodium titanates (NTO). For cathodes materials based on manganese or nickel
- For testing also, some commercial materials like Custom Cells electrodes

*Dear prof. Kazda (but perhaps also a question to prof. Braga) - if the current lithium-ion battery technology will be replaced in the future with sodium, sulphur, solid-state technology etc. How do you think it will impact battery production in gigafactories? And mining/processing of the active materials. What impact could it have on future job roles and skills? Thank you!*

- That is a very good and complex question
- If you want to build a gigafactory, you also need to **do the research,** not only the production
- You can apply these technologies faster if you have a big gigafactory and small production line for optimisation and testing new technologies. It brings added value to the country/region near the factory
- If someone developed perfect technology, you do not shut down the gigafactory and rebuild it to this new technology. Massive investments
  - It is better to make only minor changes in the production (perhaps different cathode material). For Li-S, the process is **totally different**
- Production is also impacted by the price and availability of raw materials – for example; everyone talks about Na-ion because we have a **lot of sodium**
  - We can have electrode materials with enormous energy density, but these materials are scarce and really expensive – no one would like to build a gigafactory based on this technology (no sense to make it in actual application overall)
- Helena Braga: new technologies have to be those that use the maximum of what is already there, but some rapid changes will be necessary
  - Example of semiconductors

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*Dear prof. Kazda, you mention some training at the university level; still, more technical skills at the intermediate level must be needed. If you are aware, could you tell us anything about that level of education in the Czech Republic or other EU countries? Thank you*

- There must be changes in education in university fields but also **high schools** (technical)
- Minimal knowledge for technical people:
    - **What is the battery, how it works, what is the working voltage, what are safety issues, how to handle the battery**
    - Very important to know the basics of batteries, so they can safely work with them. Be comfortable working with batteries
- **Students are scared** to take courses on topics related to batteries – they do not know much about it, they are scared about the complexity, about chemistry and so on
    - Some parts are mainly based on **chemistry**, but some parts are based on **electrical engineering**

*Dear Prof. Kazda and/or Braga, is the widening range of applications with electrification potential (aerospace etc.) going to favour certain specific battery technologies (other than Li-ion) in the future?*

- For space applications, nickel-hydrogen batteries are used
    - Slowly being replaced with Li-ion
- Based on communication with companies dealing with the electrification of **planes** (3 companies in the Czech Republic):
    - They are looking for batteries with high energy density (400 Wh/kg) – we may not be able to reach these densities with standard Li-ions.
    - This could be possible with **solid-state** electrolyte and **lithium anode**
    - With standard technology, we can reach about 350 Wh/kg, but we have to change to different technology
- It really depends on the application – for space; it will be different battery technology for satellites that operate for around one year and for deep space applications that can operate for many years (10-15)
- Helena Braga: **Space applications** are best for testing some technologies, especially **structural batteries** (centre of mass)
    - If you test it in the space, it will be much different if you than use it in facilities (houses)

*Hello, everyone. Dear Tomas, let me ask you one question about recycling - do you expect a more difficult **recycling process for solid-state batteries** than for Li-Ion? Thanks!*

- It really depends on the recycling technology
- Right now, the standard is **shredding** the battery and then separating different particles (metals, polymers, black mass) by different techniques
- It could be the same for solid-state, but for batteries with **metallic lithium**, it will be more reactive. Some technologies are used for deactivation (cryo technology to deactivate the lithium in primary batteries - you freeze the battery, and then it can be easily shredded even with metal lithium)

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- Before shredding, it is necessary to do a **deep discharge** of the battery (otherwise can be very dangerous – flammable)
    - Shredding in the nitrogen atmosphere, burning the battery as it is
- Direct recycling – spread the battery (disassemble), remove the electrolyte
    - For solid-state, it will depend on the technology of the solid electrolyte
    - It could be cost-effective if you prepare a recycling line for a particular type of batteries
        - 2 million EVs with the same batteries, you can set up the line and direct recycle all of those batteries. Much better than shredding
- Otherwise, you need to go for the pyrometallurgical or hydrometallurgical technologies
    - For solid-state, these technologies will be more or less the same
    - Only minor adjustments need to be made.
- Helena Braga: The whole question is about + and – and how to find the balance

*Dear Professor Kazda. In our opinion, What aspect and/or skill do you consider to be key for rapid and sustainable integration of batteries as efficient energy storage devices into the most diverse intermittent power generation grid, such as photovoltaics and wind power?*

- Complex question - not only about batteries but also about all other energy storage systems and renewable energy sources
    - For this $CO_2$-sustainable society, it is necessary to connect all problems together
- We need people with deep skills in each of the technology, but also people with not that deep skills or knowledge (people who know something about batteries, photovoltaics, BMS, and converters…to be able to close the loop and communicate with all of the people in the process)
- For example, in Northvolt, they have been looking for people with **specific deep knowledge**, but also for people with a **very wide knowledge** to communicate with different sectors and connect them together
- **All the skills are needed** – there is a place for everyone. Everyone could grow from basic knowledge

**Answers from Assoc. Prof. Tomas Kazda, after the interview (in writing)**

*What do you think about BMS - should it change according to the technology like lithium-ion, solid-state or flow batteries?*

- The **BMS** must be adapted to the technology as each technology has its own specificities, whether in terms of working voltage window or the shape of the discharge characteristic and sensitivity to a specific type of use.

*I would like to ask about drivers of change like **Russia Ukraine war** and its effect on battery development*

- The war in Ukraine has intensified efforts to switch to renewable energy sources, leading to a reduction in dependence on fossil fuels, which is valid for the whole EU.


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- As a result, many people, including politicians and people from companies who were sceptical about modern technologies in the energy and transport sector (renewables, BESS, EVs), have **changed their mindset** and see their development as a fact to be taken into account in the coming years.
- In the Czech Republic, the sale of solar panels for households has clearly increased, and even in previous years, people were hesitant about photovoltaics, so nowadays, these installations are trendy.

*Can you also tell us your view concerning European battery **recycling programs**?*

- There are currently many recycling projects in the EU, and recycling is crucial for the future development of the battery industry, both in terms of reducing dependence on foreign sources of raw materials and reducing the $CO_2$ footprint compared to primary mining.
- There are currently several recycling projects in the EU, and recycling is crucial for the future development of the battery industry, both in terms of reducing dependence on foreign sources of raw materials and reducing the $CO_2$ footprint compared to primary extraction.
- The EU is a world leader in recycling in terms of the **pressure to use recycled materials** for the production of new batteries. In addition, new technologies with higher recycling efficiencies are gradually being introduced.
- However, the most significant development will come in **5-10 years** when batteries from electric vehicles produced in previous years will start to be ready for recycling.
- The number of batteries to be recycled will increase, **economies of scale** will become apparent, and newer and more efficient methods, such as direct recycling, can be applied.

## Key findings

- Future battery technologies currently researched include **advanced lithium-ion, sodium-ion, lithium-sulphur, lithium-metal, solid state** and **structural batteries**
- The Czech Republic has a history of coal mining and relevant education and pieces of training available. As coal mining is being phased out, these courses can be switched, and the workers **re/up-skilled** to mining and processing raw materials for batteries since there are deposits of lithium, manganese, graphite and cobalt.
- Some students **are worried** about taking courses on topics related to batteries – they do not know much about it, and they worry about the complexity, chemistry and so on
- The industry is looking for people with specific **deep knowledge**, but also for people with a **very wide knowledge** to communicate with different sectors and connect them together
- **Minimal training** for technical people shall include training on what the battery is, how it works, what is the working voltage, what safety issues are, how to handle the battery

The following job roles were identified in the interview:



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- **Electrical engineering**
- **Chemical engineering**



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## 3 Future Battery Technologies – Interview with Prof. Dr Noshin Omar

*Agenda*


**Figure 3:Agenda of the interview**

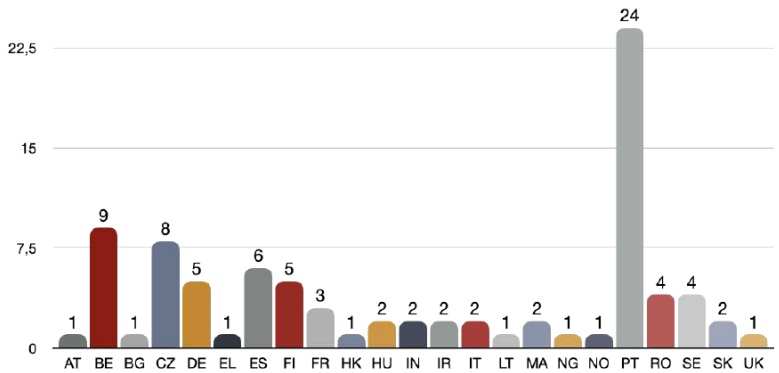
*Purpose of the interview*

The purpose of this interview is to provide a discussion about the current and the new trends in battery technologies and the production and recycling of batteries

*Why was the topic chosen?*

To explore the trends in battery-relevant start-up and Research & Development areas and relevant job roles, skills and knowledge needs.

*Registrations*

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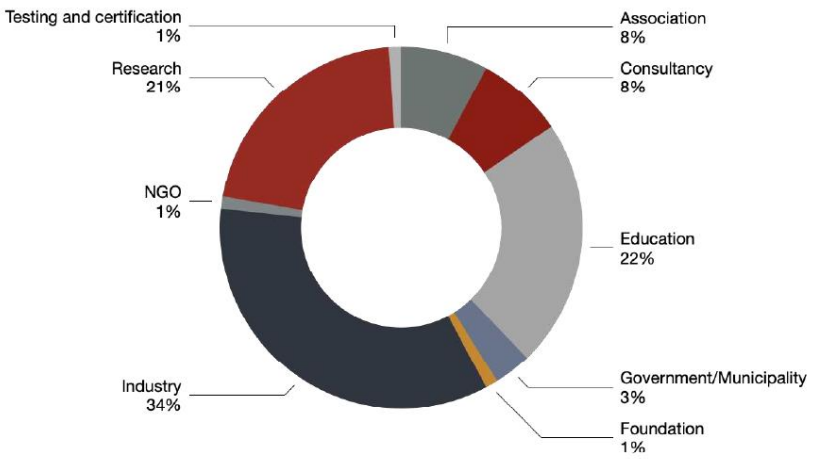


**Figure 4: Number of registrations and their distribution by sector**

*Participation*

The number of participants via the Webex online platform was **54;** other viewers followed the event's live stream on Facebook. Others have been accessing the recording on the ALBATTS website. The stream remains available there for further viewers.

*The Interviewer*

**Prof. Dr Maria Helena Braga,** University of Porto

*The Interviewee*

**Prof. Dr Noshin Omar**

- Obtained his M.S. degree in Electronics and Mechanics from Erasmus University College Brussels. Obtained his PhD in 2012 in rechargeable energy storage systems from the department of Electrical Engineering and Energy Technology ETEC, Vrije Universiteit Brussel. He is the formal director of the Battery Innovation Center of VUB.
- Currently, he is working as an associate professor at Mondragon University, and he is the founder and CEO of Avesta Battery & Energy Engineering (ABEE), which focuses on batteries and energy technologies. In addition, he is the author of more than 140 scientific publications.



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## The interview

*Will the battery keep on changing the world?*

- He fully believes that they will change the world
- Energy is vital – batteries have a crucial role in the energy transition
- Different energy conversion technologies – the critical role of batteries in meeting objectives (energy security)
- The sustainable way of manufacturing will be the key
- Li-ion technology will be improved by 2030, then slow transition (step by step) to another technology (**Silicon-based anode** and solid states)
    - Requiring upgrade of equipment, facilities
- **Advanced Li-ion** technology will fill up the market until 2030
- Jump to **solid state** is not easy – different technology, different supplies… many needs in skills
- Need for supply chains for new technologies
    - The current supply chain needs to evolve a lot

*Start from the beginning – any advice?*

- Be much more ambitious – market demand is very aggressive
- Industry demand is very aggressive, big and fast

*Starting a gigafactory – what are the critical points - location, people, supply…?*

- Location is critical - nearly every location deserves to have a gigafactory
- **Location** is also crucial because of the supply chain of **raw materials**
- Access to raw materials and **clean energy** is needed to achieve European emission goals and be successful
- The biggest challenge is to set up the **stable supply chain**

*The different processes of lithium mining in Europe – if you can talk with the politicians, what pluses will you say to convince the people?*

- In many areas, mining is not sustainable and human (the same for cobalt and nickel…)
- Everything needs to be done **humanly and sustainably** (from mining to manufacturing to recycling) – a key element to the whole industry, not only the battery industry

*Recycling*

- Everything over 20 kg has to be recycled (by law)
- End of Life management
- Rejected materials from production (production scrap) – rejected electrodes, electrolyte, separators… **high-value waste** – significant to recycle and return to the process as input material
- Recycling of finalised battery packs as well – aluminium, plastic…
- **Recycling hub** needs to be in **every region or country** – many customers and producers are looking for a sustainable and green way

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- Transport is also a problem – recycling in every country/region to lower the footprint from the **transport of e-waste**
- Recycling will be cheaper in the future

*Reskilling of the industry workforce*

- Education of future engineers and chemists is the key to success
- Better engineers in China and Japan – need to have more European engineers
    - There are lots of gigafactories in the EU, but **knowledge is in Asia**; Europe should create **a coordinated plan** to make the industry more planned and coordinated (from raw materials to battery recycling)
- Adapting the curricula - there is still time to adapt
- Adaptation of the academy to the needs of industry (better collaboration)
- Role of universities in developing basic knowledge
- Covid shows that we need to be more independent from Asia and India. The same problem as with semiconductors

*Added value to lithium mining, building gigafactories in Europe to be more independent*

- We in Europe have to work strategically – to **prevent collapse** (as with the semiconductors)
- With semiconductors, we should have started ten years ago…
- We as a continent should face problems together (not enough cobalt, lithium, nickel…)
- Geographically we **do not have the advantage**, so we need to cooperate

*Lithium is considered white gold. Sodium is a thousand times more available – why not sodium?*

*Will it replace lithium?*

- Advanced LFP technology will be produced
- Not every car needs NMC technology – city cars can run on LFP
    - Europe shall not produce NMC; there should be LFP technology too
- Will sodium be needed? – Definitely – a mix of different technologies
    - NMC, LFP, Sodium and also Li-S…
    - **Sodium for stationary, low-performance mobility**…possibly good for low-cost applications
- Pushing research programs on the European level is needed

*How do you prepare people? How to succeed?*

- Moving in the same way as other companies – not an option
- You need to decide how you will **differentiate from others**
- Big mistake – everyone is doing the same technology – his gigafactory is trying to make something different
- For ABEE it was **LFP**; no other EU project is based on that technology

*When do you see the price of batteries in cars dropping? The battery is one of the most expensive parts of an EV, and people know about it. Do you have a vision?*

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- 10 years ago, 100 Euro/kWh, now dropping
- Target **70 Euro/kWh**
- Battery price will be dropping but will hit specific bottom
- The industry will make a considerable effort to reach the target (for example, by **mass production**)

*The warranty of the battery in EV is more extended than for conventional vehicles; the second life of batteries*

- Some battery technologies can have a longer life than the rest of the vehicle (4-5k cycles), but this is not the way
- Today is the second life expensive due to manual repair
- For now, the best way how to get the circular economy goal - a big fan of second-life batteries

*Raw materials: How do you see reskilling of people – some European effort? People do not see the good in mining raw materials in their country…they have good water and air… what should we say to them to be positive about mining?*

- The situation has to be improved in a sustainable and human way. Very important
- **No raw materials = no batteries**
- All is about sustainability
- Europe's automotive industry is doing really well
- Also, training and education of people
- Hoping that in the future, there will be many more projects as ALBATTS etc., to share information and inform people

*How do you manage the writing and planning of a project?*

- Start on time with **methodology, technology,** and **consortium** around that…make a step-by-step plan, and take your time to write it
- Lot of attention to the impact and dissemination
- The way of writing a project is different every time – need to adapt it (every year it is different)

*Things are changing, but not enough. So what upskilling should be done by the industry?*

- Dedicated programmes led by the industry
- Cost much money – considerable steps in skills
- Big **gap in programmes 5** to **7-8**

*What is the role, and how can European Commission regulate the market*

- The **industry is changing** quite a lot and very fast; **regulations are lagging behind**
- Much more interactive interaction is needed between the **industry and the European Commission** to make everything on time

*Future*



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- Technology will be different
- Everything will be more **digitalised**

## Questions from the chat

*Prof. Noshin Omar - you mentioned 200 employees in the ABEE facility. What battery-relevant job roles, competencies and skills have you been finding the most difficult to find?*

- **Chemical engineers, electrochemical engineers, cell designers, electrical engineers, process engineers, modelling and thermo-management**
- People with good background

*Prof. Omar, what is your opinion about the necessity (or not) for a gigafactory on **recycling**: to have its own operations or to cooperate with a third party company (this activity needs specialised staff and not only)?*

- You are not dealing with end-of-life batteries only but also with **production waste**
- Cooperation and sharing of industrial property
- Industrial property sensitive topic
- Very challenging aspect

*How do you plan to address the **inclusion of recycled raw materials** in your batteries under the new regulation?*

- The batteries from end-of-life or production waste have to be recycled
- Separation of materials, how they can be used – back to the manufacturing or something else
- Recycling of **55 %** - as input material. Vision is the same as lead acid (**nearly 100 %)**

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*Dear Prof. Noshin, Thank you for this interesting talk. What is the perfect time/education level for academic people who believe in the importance of the industry to* ***transfer towards the R&D - industry****?*

- After finishing your PhD, wait maximum 1-2 years, then jump to the industry

*Dear Professor, first of all, thank you for your nice talk ...Could you please elaborate if the application of batteries will be possible in heavy vehicles.*

- Fully electric city busses already exist
- For a heavy **truck range to 200-300 km**, then it should switch to another technology (for example, **hydrogen**)
- Marine sector: **small ships**, not cruisers or cross-pacific ships…for those applications, hydrogen seems to be the way
- Job roles hard to find include **chemical engineers, electrochemical engineers, cell designers, electrical engineers, process engineers, modelling** and **thermo-management**

**Information about the event and a video stream can be found on the website of the ALBATTS project.**

## Key findings

- Li-ion technology will be improved by 2030, then slow transition (step by step) to another technology (**Silicon-based anode** and solid states)
- Jump to **solid state** is not easy – different technology, different supplies… many needs in skills
- The biggest challenge when building a gigafactory is to ensure a **stable supply chain**
- **A recycling hub** needs to be in every region or country to lower the footprint from the transport of waste
- **Sodium** technology to be used for **stationary** applications and **low-performance mobility**
- **Mass production** of batteries to lower their costs
- There is a **big gap** in programmes in education **levels 5** to **7-8**
- The industry is **changing** very fast; regulations are **lagging behind. More industry - EU Commission** is needed
- Ranges up to **200 – 300 km** are suitable for **electric trucks**; for longer ranges, hydrogen might be more suitable, similar to maritime vessels

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The following job roles and skills were identified in the interview:

- **Chemical engineers**
- **Electrochemical engineers**
- **Cell designers**
- **Electrical engineers**
- **Process engineers**
- **Modelling**
- **Thermo-management**

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# 4 Webinar Electrification of the Aviation Sector

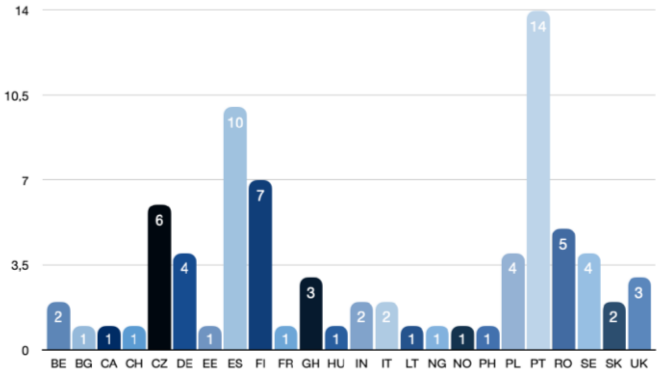
*Agenda*


**Figure 5: Agenda of the webinar**

*Purpose of the workshop*

To learn about the electrification of aeroplanes and drones and relevant challenges concerning technical aspects of the application of batteries and relevant job roles, skills and knowledge needed from the perspective of start-ups.

*Registrations*



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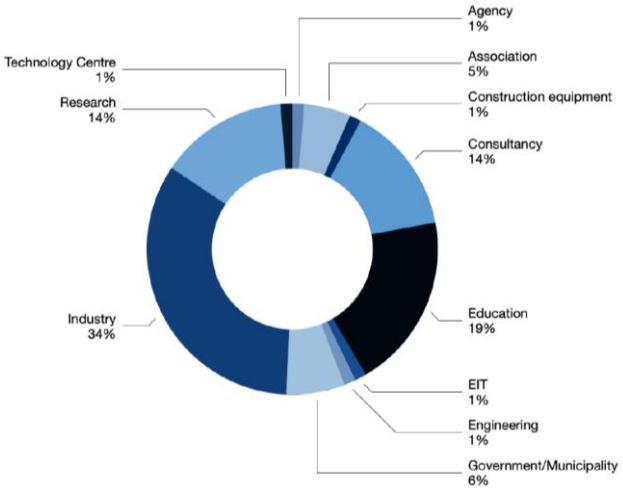


**Figure 6: Number of registrations and their distribution by sector**

*Participation*

The number of participants via the Webex online platform was **42;** other viewers followed the event's live stream on Facebook. Others have been accessing the recording on the ALBATTS website. The stream remains available there for further viewers.

*Moderator:* Jakub Gajdušek

*Introduction of the ALBATTS project:* Lukáš Folbrecht

*Speakers:* Michal Illich and Tobias Kahnert


**Figure 7: Moderator and speakers' BIOs**



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## Key messages

**Michal Illich – founder of a start-up ZURI**

- ZURI: 8 tiltable electric motors – **vertical take-off and landing** (as a helicopter), flight with the efficiency of an aeroplane
    - Vertical take-off
    - Hybrid
    - **700+** km range
    - Passenger version (1 pilot, 4 passengers); Cargo (larger doors for 2 pallets – 350 kg); Search and rescue (3x cheaper to operate, easy access)
    - Flight-tested many prototypes (on cables)
    - Started to build it
- Timeline: 2018-2021 R&D; 2022 prototyping; 2024 Hybrid VTOL large scale prototype; 2025 – Production
- The high energy density of hybrid powertrain (**1,360 Wh/kg**) – 7× higher range than fully electric VTOLs
    - Best batteries 230-280 Wh/kg
- 3-times cheaper to purchase and operate than a helicopter
    - Quitter than helicopter
    - It does not need an airport

**Tobias Kahnert – Founder and CEO of Electric Flytrain**

- Has a team with much experience from the automotive industry
    - Himself: 4 years in the **powertrain department of Tesla**; others worked for companies such as BMW and Siemens
- Developing the powertrain itself, not the aircraft
- Investors from the aviation industry
    - Expansive network and experience
- Two foundations
    - Development partner of electric powertrains to existing aircraft manufacturers and hybrid electric powertrains by Electric Flytrain
- Hybrid-electric powertrains – **High payload** + high flight times (**more than 5 hours**)
- 3 main types of **drones**: Search and Rescue (Police, Emergency); Crop Spraying (Agriculture) and Payloads (Logistics)
- Payload × Air time graph
    - Higher payload = shorter air time (1.5 hours with 20 kg)
- Development timeline
- Focus areas: **Power train architecture**; **Battery design** (mainly for the aviation industry); **Controller development** (master controller in the power train that controls all of the sub-components)
- Battery technology selection in aviation
    - Step-by-step plan

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- Determining all relevant system parameters (Specific Power; Specific Energy, Safety, Voltage – max, min, nominal; Temperature range – storing and using; Calendar life and Maintenance; Cycle life; Applications; Cost)
- Certification standards – picture of how to identify standards and guidelines for batteries in electric aviation

## Questions from the moderator and the chat

*How do you deal with the low energy density of lithium batteries? Isn't it a big problem for the range of electric flying vehicles? Since they have to lift the weight of the battery*

Michal Illich:

- **Hybrid** way – combine both energy sources (battery + turbogenerator)

Tobias Kahnert:

- Agree with Michal – hybrid is the way
- Long range is still a problem
- Batteries have their limitations

*Do you think they (ZURI) can also be used as taxis? To Michal*

- Of course, however, travelling for a short distance (20 km) is not worth travelling
- Primary focus on **longer distances** (hundreds of km)

*Michal, what kind of battery technology have you been using, and where are they stored in the aircraft? What is the battery capacity?*

Michal Illich

- Standard Li-ion with the higher power, the same as in EVs
- Capacity around **80 kWh** or less (smaller than in EVs)

Tobias Kahnet

- The focus on power density
- Capacity depends on the project (1 kWh to several tens-hundreds of kWh)

*Do any of you have in mind what to do or how to recycle/reuse the batteries after their life ends? Sometimes batteries are tough to dismantle and reuse because of the tight manufacturing.*

Michal Illich

- Call with battery manufacturer: The best case scenario: use the battery for around 500 cycles, then the battery partner provides a new battery back and uses the old one for another application (home storage from photovoltaic…)

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Tobias Kahnet:

- High potential to second life – Different regulation processes between aircraft, automotive and home solutions…

*Tobias and/or Michal, what particular skills are required from pilots/ground crew due to the use of batteries in these aircraft*

Michal Illich

- For the pilot, nothing changes much - mainly for the ground crew
    - Do not touch the battery! – **High voltage**, so only skilled persons can handle the batteries or work around them

Tobias Kahnet

- Ground crew have to be specially trained to work with batteries

*Tobias and/or Michal, do atmospheric conditions (such as rapidly changing temperatures, storms, lightning) provide any added challenges, particularly to electric-hybrid aircraft, compared to traditional jet or propel propulsion planes?*

Tobias Kahnet:

- Some challenges are there – mainly lightning protection of all systems
    - Different from the automotive industry
    - In aviation, you have to expect how the weather will change
    - The advantage - no need for oxygen for the electric motor

*Skilled people?*

Michal Illich

- In the Czech Republic, there are many industries and universities – so many skilled people

Thobias Kahnet

- Elevating people from the **automotive industry** to the **aviation industry** is a big challenge

*Hydrogen?*

Michal Illich

- **Sceptical about hydrogen** systems – the problem is not with hydrogen itself, but with the really **heavy hydrogen tanks**. Weight is the main problem in the aviation industry
    - Liquid hydrogen – lighter tanks, but a problem with temperature management (compression, decompression, pressures, temperatures…)



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## Key findings

- Electrification of aircraft (hybrid) allows for **new aeroplane concepts**, such as those with **vertical** take-off and landing
- Air taxis for a very **short distance** (up to 20 km) are not economically viable
- The battery capacity of around **80 kWh** or less (smaller than in most EVs) for a small passenger/cargo aeroplane
- No special training for the pilot is needed. However, the **ground crew** must know the basics – not touching the **high-voltage** battery, etc.
- The **automotive industry** can be the source of some of the relevant skills. Getting skilled people from the automotive industry to the **aviation industry** is a big challenge
- Heavy hydrogen tanks complicate a broader use of **hydrogen** in aircraft

The following job roles and skills were identified in the webinar:

- **Power train architect**
- **Battery designer**
- **Controller development**

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# 5 Webinar Electrification of Heavy-Duty Vehicles

*Agenda*

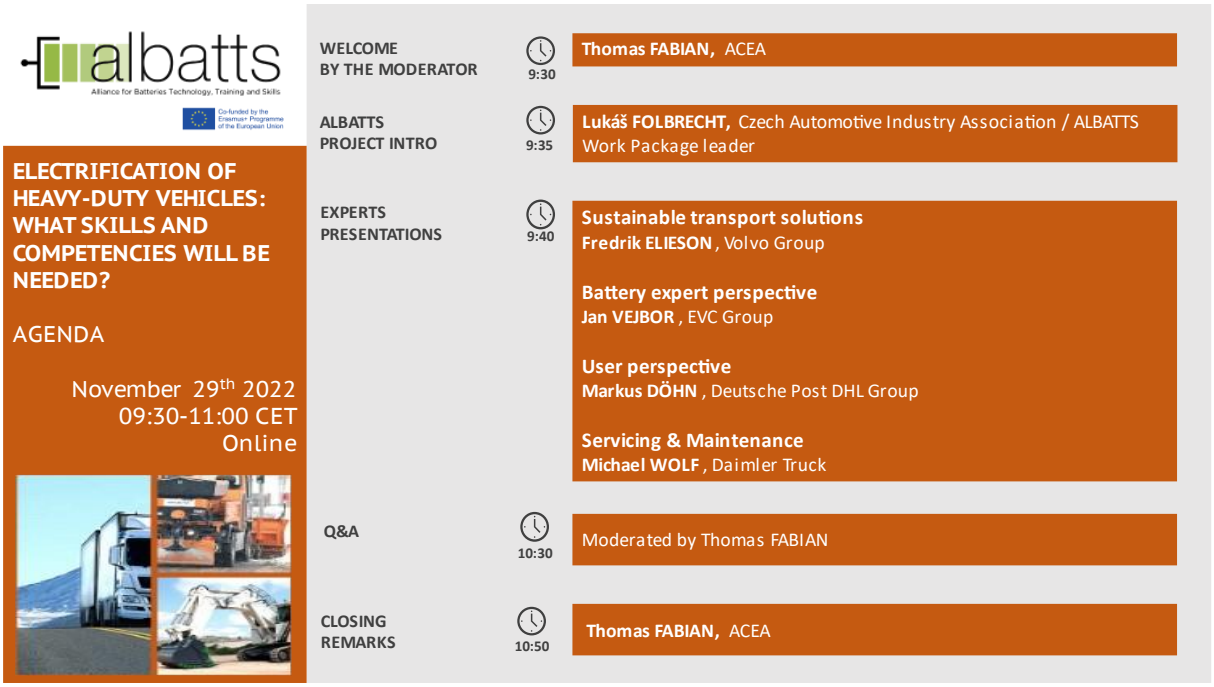
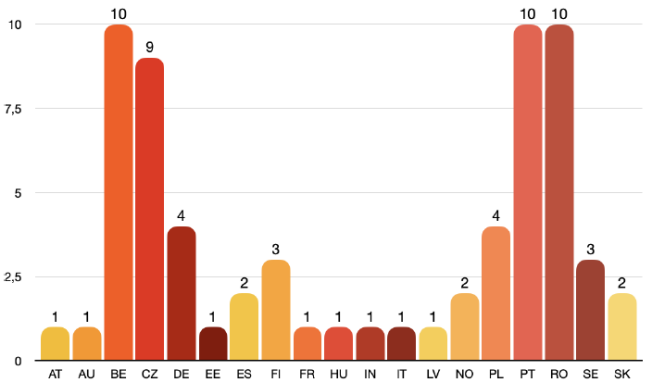



**Figure 8: Agenda of the webinar**

*Purpose of the workshop*

This webinar was organised to explore the electrification of heavy-duty vehicles, particularly battery trucks and buses, and address the job roles & skills needed to succeed in the electrification of the freight segment. Vehicle manufacturing, application of the batteries into the vehicle and servicing & maintenance were also to be discussed from the user perspective.

*Registrations*



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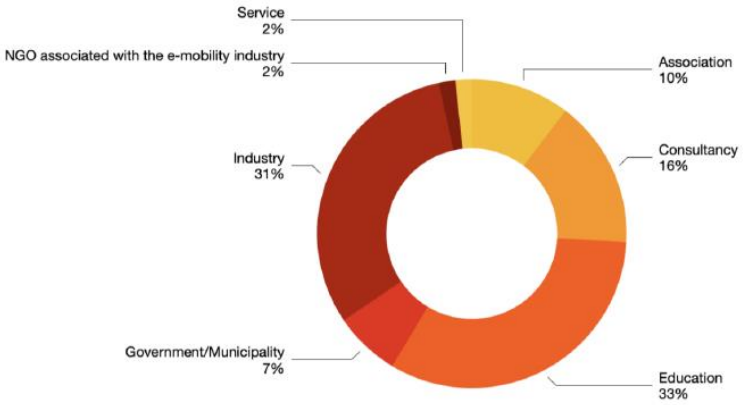


**Figure 9: Number of registrations and their distribution by sector**

*Participation*

The number of participants via the Webex online platform was **54;** other viewers followed the event's live stream on Facebook. Others have been accessing the recording on the ALBATTS website. The stream remains available there for further viewers.

*Moderator, speakers*

**Thomas FABIAN** joined the European Automobile Manufacturers' Association (ACEA) as Commercial Vehicle Director in November 2018. ACEA represents the EU's seven major truck producers.
In previous roles, Thomas served as: Head of the Department Commercial Vehicles, Trailers, Bodies and Buses of the German Association of the Automotive Industry (VDA); Secretary General of the International Association of the Body and Trailer Building Industry (CLCCR); Director Transport Policy for the German Airports Association (ADV); and Senior Manager Transport Policy for the Federation of German Industries (BDI). Before that, he worked as Scientific Advisor to a member of the German Parliament.
Thomas holds a degree in transport engineering of the Technical University of Berlin and has been working on international transport policy projects ever since graduating in 2000.

**Lukáš FOLBRECHT** has been leading ALBATTS project Work Package 5 – Intelligence in Mobile Battery Applications, which has been analysing the use of battery technologies and relevant job roles and skills in moving devices, such as electric passenger cars, buses, trucks, but also motorcycles, aerospace, trains and city micromobility devices across their whole value chain. His previous experience includes positions in SKODA AUTO, the Office of the Government of the Czech Republic and the media, as well as work and study experience in the US, the UK and Brussels. Lukas is also a secretary of the Czech E-mobility Platform and an e-mobility enthusiast.

**Fredrik ELIESON** is Responsible Competence Transformation & Senior Project Manager at Volvo Group Operations. With more than 20 years of experience from different leading positions in industrial- and digitally-based start-up organisations in the automotive industry by establishing new organisations into stable and profitable business operations in a global environment. Fredrik is supporting the organisational competence readiness for the future by enabling access to valuable and individualised competence solutions and government funding to support the transformation journey. Since 2014, he has worked with the competence development of employees and organisations through building-up Volvo Group University. He is leading several competence transformation initiatives to secure the readiness and financial funding for the ongoing technology shift in the automotive manufacturing industry. Additionally, Fredrik has experience from several leading positions in building up industrial and technology start-ups plus leading positions in the financial areas being CFO and investment director in the venture capital profession.

**Markus DÖHN** is a Senior Expert Electromobility at the Deutsche Post DHL Group, where he started working in 2008. Previously to that, he had been working for four years at the Deutsche Post as a Consultant. He studied at the Europäische Hochschulen, where he got his diploma.

**Jan VEJBOR** is EVC Group Head of Sales and member of board of the Czech Battery Cluster. In more than 15 years in e-mobility and RSE market, Jan specialises in sales of traction battery systems for personal and heavy-duty vehicles, the scope being recently widened by home and industry ESS portfolio. Being in contact with li-ion cell producers and with cell recycling companies, Jan focuses on the overall picture of the li-ion battery life-cycle.

**Michael WOLF** is R&D project manager zero emission vehicles at Daimler Truck AG and, after many years of experience in developing heavy duty trucks and light vans at Daimler Trucks, he is fully inspired to be part of the transformation in the commercial vehicle industry. As a technical project manager of the Mercedes-Benz eActros long-haul, he is facing all aspects of challenges regarding technology, organisation and volatile market environments. Michael believes in the future of zero emission transportation and supports the Paris climate goals.

Figure 10: Moderator and speakers' BIOs

## Key messages

### Frederik Elieson

- E-bus since 2007, trucks since 2019
- Competences – change needs to be everywhere, not only in manufacturing
    - At all positions
- Many opportunities – new business models, new work positions
- **Safety** with electrification, battery knowledge, manipulations with the batteries
- Opportunities to learn from other brands and cooperate for better results
- 2 challenges: **Reskill people** from different positions and **upskill people** for a more efficient way of working
- Upskilling and reskilling is a kind of puzzle of three pieces that need to be connected
- Not one solution – many types
    - Different kinds of **competence levels** – **experts/specialists** in specific areas
    - Many people with **general knowledge**
    - Specific knowledge people – production, workshop, engineering sites
- **Partnership with universities** to ensure this knowledge – is fundamental for the transition



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- Working on many fronts: Skill boost and development; Digitalisation of Work; New ways of working; Innovation incubator; Multiple resource solutions; Footprint utilisation
- Acceleration is the key; speed is the challenge
- A lot of the knowledge based on past experience
    - "We can build the electric truck, but we have to sell the truck as well" – skill from manufacturing to sales management

**Jan Vejbor**

- Experience with 600+ successful traction heavy-duty battery applications so far
    - 3 shapes of Li-ion: Cilindrical, pouch and prismatic
    - Mixed chemistry (NMC, LFP…)
    - Heavy duty vehicles = daily usage = need to be **100 % sure** that it will work
- The essential skill of electrification of heavy-duty vehicles = **business** and **technical**
- Battery: a. costly, b. hard to get
- Very important to **understand the assignment** from the client
    - Clients are often not able to directly tell their needs
- Good **project leadership** is the key

**Marcus Döhn**

- High reliability, **cannot afford** breakdowns
- A high amount of trucks **operating at the same time** – newly acquired trucks will be **electric** or with some level of electrification
- Many challenges
- 3 types of vehicles in DHL (Small, medium, large)
    - Small: **Electric Van** (4.25 t) – in Germany
        - Up to 70 vehicles per depo (the challenge for the next 10 years)
    - Medium: **Electric Trucks** (16 t) – In the UK
        - Overnight charging – **22 kW AC** (not stressing the grid too much)
    - Large: **Electric Trucks** (60 t) – Sweden
        - High charging power (**350 kW DC**)
        - High consumption amplitude
- Trucks are getting bigger (every square yard costs money)
- Need to have a stable **source of energy** – for building and for charging trucks as well – **energy management** is vital
    - The energy consumption often exceeds the consumption of a whole building
- **Driving** an electric truck is way **easier** than driving a diesel truck
    - Drivers are **satisfied**
- External conditions – summer and winter – influence the performance of an electric truck
- Challenges with charging currents
- Not at all worries about batteries – they are very well manufactured and very **reliable**

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**Michael Wolf**

- $CO_2$ neutrality in Europe by 2039
- **2030 – 60 %** of vehicles ZEV, **2039 - 100 %**
    - Very short time for such an industry
    - Ramp-up is speedy
- Started at Urban Areas (eActros in the past; eEconic right now), moving to Long Distance Transport (eActros Long Haul, GenH2 Truck)
- Transformation to ZEV needs new competencies in **R&D**
    - RaD aspects – new technologies (ePowertrain); H2 tanks/fuel cells; batteries for heavy-duty trucks is one of the very fundamental starting points
    - **Mass and safety** of the batteries are the main challenges
    - Much discussion about **sound design**
- Huge batteries – need to speak with suppliers to guarantee the **safety and integration**
- Digitalisation is essential (use case analysis)
    - Avoiding breakdowns and **predictive maintenance** (**digital twin**)
    - How to keep the truck on the road for as long as possible
    - How the **charging infrastructure in the depots** should look like
        - Out of the way / between vehicles / at an angle / drive through
- After-sales
    - You cant sell the truck without after-sales – the **reliability** of the vehicle is the key
    - **Workshops/training** on EV components, hydrogen components, **building the infrastructure**…
    - **Driver training** – significant impact, how the driver drives the EV
        - Already changed the truck training programme for electric vehicles

## Questions from the moderator and the chat

*Recycling is a very actual topic. Difference between heavy-duty vehicle batteries in comparison with passenger vehicles. Usage, performance, recycling?*

Frederic Elieson

- Used batteries sold to another application – to use it in a good way (2nd life)
    - Crucial area – battery used for a while, then needs to be replaced
    - Finding new segments where the batteries can be used – energy storage

Michael Wolf

- We have to **increase the lifetime** of such battery packs (costly batteries) – use them for the whole lifetime of the truck
    - High charging cycles for batteries
    - Good recycling is the key – make a **closed loop** in the future
        - All **materials** are needed

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Jan Vejbor – high voltage aspects

- Heavy-duty batteries operate on higher voltage (above **500 V**). In the past, in passenger vehicles, the battery voltage was under 500 V, now they are starting to go **800 V** – specific impact on second life application in energy storage for buildings
    - Heavy-duty vehicle battery for energy storage – expecting high voltage – you can directly use the battery (**no need for serial connection** of multiple batteries to increase the voltage)
    - You can not only programme the size and parameters of the battery for the first life, but you can **plan it for the second life** as well
        - Mystification: any time you take the battery out of the first service, they can well be suited for a second life – it is not truth
        - Instead: you gain more usability of the battery in the second life if you think about it **in advance** because two main risks arise as the battery gets older
            - Higher **internal resistance** – more heat is evolved while using – you spend more energy to cool the battery = higher energy loses
            - Limited shelf life – degradation of the **physical shape** – delamination, leakage of electrolyte…
- Recycling – pilot recycling in the Czech Republic (Kovohutě Příbram company)
        - Challenges – the need to discharge the battery first, no information about how the output (black mass) from recycling should look like to **get some value** of it (new business with many opportunities but also black holes)

*Do you pay particular attention to any safety-related elements when training your staff on EVs? Do you have any feedback from the operators of these vehicles?*

Markus Döhn

- Generally, any minute you spend on training will pay back
- You drive a small 4.25 t eVan with a driving licence for a 3.5 t vehicle – **mandatory training in Germany** for 5 hours
- Battery, safety aspects, after-sales – special equipment (**rubber gloves**…) – they **do not train drivers** for this because they treat eVan as if it was a diesel vehicle (constructed at the same safety level)
- Electric vehicles are way **easier to drive** and way safer than diesel vehicles

Michael Wolf

- Started the truck training - training drivers how to save energy while driving (change in **driving behaviour**)
- Safety – installed many **safety features**: monitoring, safety shutdown, electric protections
- Electric trucks are easier to drive - an excellent user **experience**

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- Once the truck driver tries the electric truck, he does not want to drive diesel anymore

*Should there be any special training concerning charging the vehicle?*

Michael Wolf

- For the driver, it is the same as today's standard – only more giant cables and plugs
- In terms of handling, is the same procedure
- **Megawatt charging** – charge up to **80 % in less than an hour** – reduce charging times to get truck back on track

Frederic Elieson

- The key is to **simplify charging** as much as possible
- Charging trucks should be as easy as charging standard EVs – the cables are only a little bit bigger
- Need to train a lot more people in **electrical safety**
- **Certification to use and also move** in an environment where **high voltage** is

*Wireless charging, dynamic charging perspectives?*

Marcus Dohn:

- **Wireless charging** = many difficulties
- Problem with the **positioning** of the vehicle (extremely critical)
- **Dynamic charging** – OEMs are responding to this plan
  - Massive investment in motorways; the technology has not been tested on the needed level
  - High energy consumption of the vehicle – to keep the SOC of the battery constant, we would need **at least 100 kW** of energy transmitted through pantographs

Michael Wolf

- Many ideas and a lot of technologies on how to charge
- In less than 10 years, all vehicles should be electric – focus on infrastructure
  - Plug charging is a proven and very known technology (only some adjustments are needed)
- Both plug charging and wireless charging are within us, so the speed is one of the most significant aspects of winning the race

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Frederic Elieson

- If **busses** go the same way every day, same stops every day…you can integrate **wireless chargers**, but with trucks, they do not always have the same way; they can go across Europe.

Jan Vejbor

- You do not want the driver of the bus to step out at the turning station or at the stop to charge the vehicle, to play with very thick cables to plug in the charger…especially when it rains or snowing
- Earlier (2010-2015), there were very progressive cities that wanted to instal charging infrastructure, but there were problems:
    - No common standard of charging**,** so if you once purchased charging stations from some manufacturers, you needed to buy only from the same ones because there were not compatible with other chargers…now it is better because we have **common standards**
- Megawatt charging comment:
    - You do need not only the power (Megawatts) but also energy (Megawatt hours)
    - You can charge buses or trucks slowly during the night, but if you have around 50 of these buses, you are getting to MWh of needed power delivery – every depo can change to a small power station
    - Megawatt chargers bring a lot of new challenges – the challenge is to bring the power

## Key findings

- Truck manufacturers are dedicated to the **decarbonisation of their fleets** using electric trucks, but also hydrogen and other alternatives
- OEMs have set internal decarbonisation targets, such as 2030 – 60 % of vehicles zero emission vehicles, **2039 - 100 %**
- Heavy duty vehicles = daily usage = need to be **100 % sure** that it will work
- Heavy-duty batteries operate on higher voltage (above **500 V**). In the past, in passenger vehicles, the battery voltage was under 500 V, now they are starting to go **800 V**
- Charging speed varies from e. g. **medium-size 16 t** trucks that can charge **22 kW AC** overnight to **large 60 t** trucks able to charge up to **350 kW DC**
- Future outlook - **Megawatt charging** – charge up to **80 %** in **less than an hour**
- Charging infrastructure in the **depots** needs to be rolled out **-** need to have a stable **source of energy** – for the building and for charging trucks as well – **energy management** is vital
- Crucial **- safety** with electrification, battery knowledge, manipulations with the batteries

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- Different kinds of **competence levels are needed - experts/specialists** in specific areas – but also many with **general knowledge**
- The essential skills for electrification of heavy-duty vehicles = **business** and **technical**
- **Driving** an electric truck is way **easier** than driving a diesel truck; drivers are **satisfied**
- **The mass and safety** of the batteries are the main challenges. **Safety features** in trucks: monitoring, safety shutdown, electric protections
- Need to avoid breakdowns - **predictive maintenance** (**digital twin**)
- **Workshops/training** on EV components, hydrogen components, **building the infrastructure**…Drivers training, driving behaviour
- Driving a small 4.25 t eVan with a driving licence for a 3.5 t vehicle – **mandatory training** in Germany for 5 hours
- **Certification** to use and also move in an environment where **high voltage** is
- **Wireless charging** = many difficulties, such as the problem with the **positioning** of the vehicle (extremely critical) – difficult/costly application in highways for trucks. More considerable potential for **busses** that go the same way and have the same stops every day

Job roles identified in the webinar

- **Electro-mechanical engineering** (*comment of a participant in an ex-post survey*)
- **Project leader**

**Training identified in the webinar**

- Mandatory training for **drivers in Germany** taking 5 hours
- Training on **EV components**, infrastructure building
- Drivers training - **driving behaviour**
- Certification to use and also move in an environment with **high voltage**



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# 6 Webinar Electrification of Inland Waterways

*Agenda*

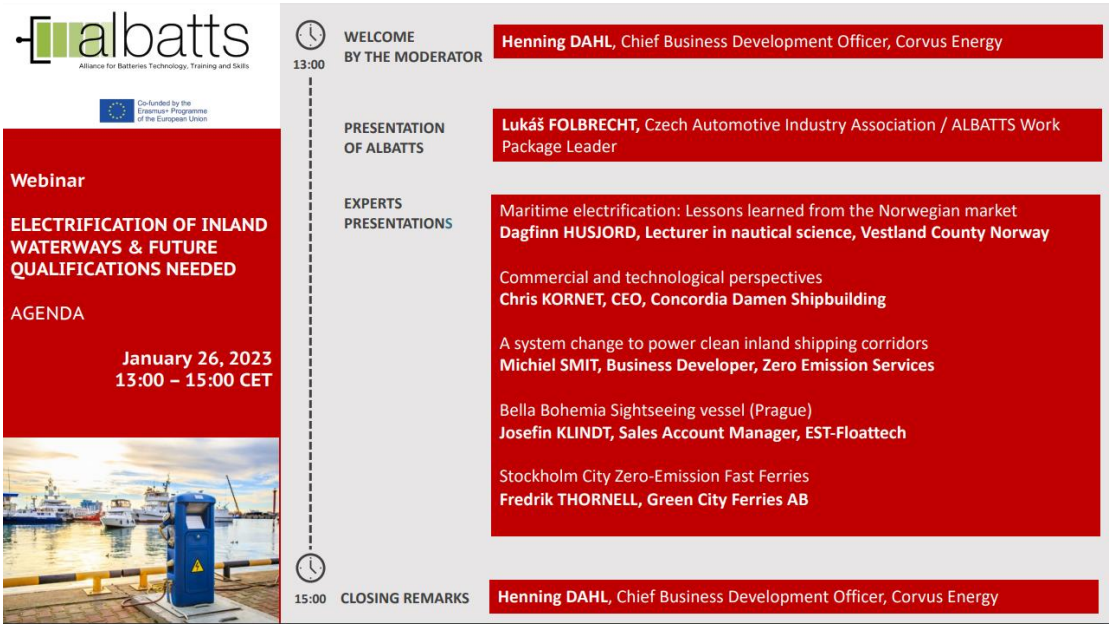
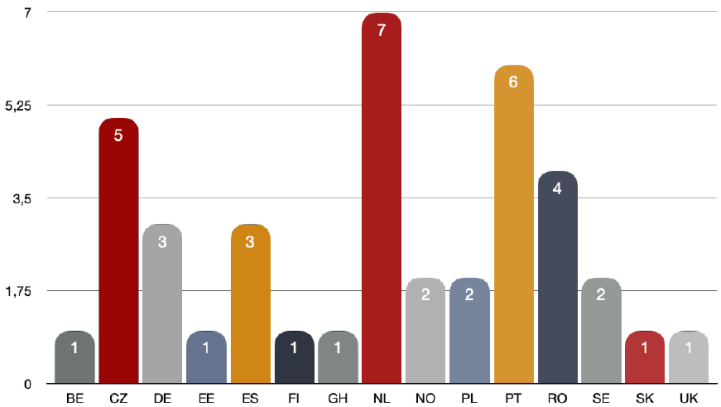



**Figure 11: Agenda of the webinar**

*Purpose of the workshop*

Inland waterways could be essential in decarbonising the European transportation system by shifting cargo and people from roads to waterways. This webinar was organised to learn more about the topic and the skills and competencies needed to achieve lower and zero emissions in inland waterways operations.

*Registrations*



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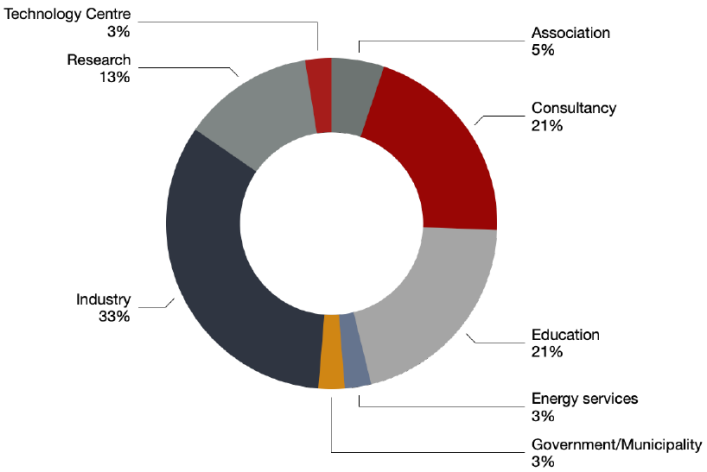
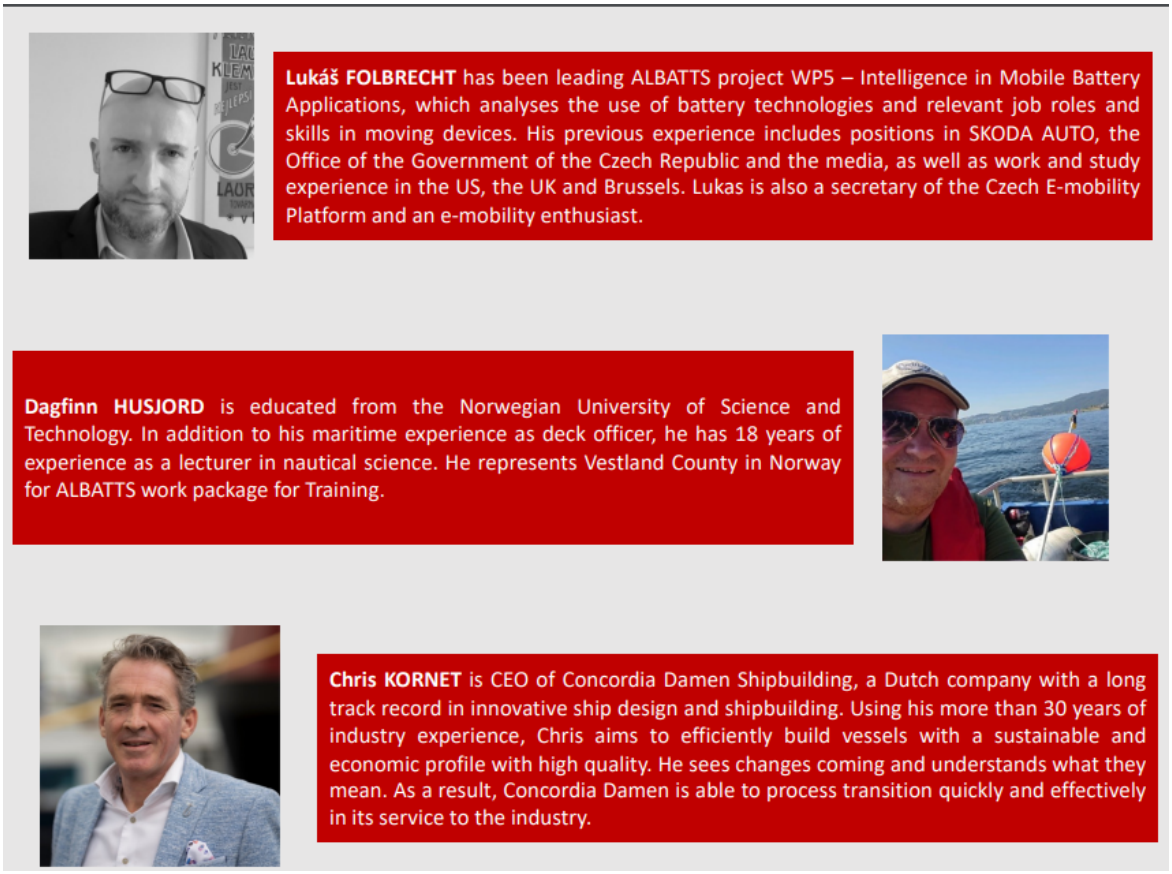



**Figure 12: Number of registrations and their distribution by sector**

*Participation*

The number of participants via the Webex online platform was **38;** other viewers followed the event's live stream on Facebook. Others have been accessing the recording on the ALBATTS website. The stream remains available there for further viewers.

*Speakers*

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**Michiel SMIT** is a Business Developer with Zero Emission Services, a Dutch company leading a system change by powering clean inland shipping corridors using swappable modular energy containers and docking infrastructure. Michiel holds a Master's degree Offshore Engineering from Delft University of Technology and with over 5 years of experience in engineering and operations he's highly driven in contributing to the shipping industry energy transition.

**Josefin KLINDT** is is Sales Account Manager for EST-Floattech in Germany. EST-Floattech is a fast-growing supplier of maritime energy storage solutions, determined to make tomorrow's shipping more sustainable. Josefin holds a shipping degree from HBT business school in Hamburg and has more than 10 years of industry experience from working for different shipping companies and as team lead for a battery manufacturer supplying to multiple industries ashore.

**Fredrik THORNELL** is founder and Executive Director of the Swedish company Green City Ferries, a Stockholm based company dedicated to efficient, sustainable waterborne mobility. GCF delivers innovative, energy-efficient, and emission-free high-speed ferries with low wake signature for protected inland and coastal waterways. Fredrik holds an Industrial Engineer degree from the Royal Institute of Technology (KTH) in Stockholm and has a background in property development including the creation of a private real estate portfolio in central Brussels.

Figure 13: Moderator and speakers' BIOs

*Moderator*

Henning Dahl, Corvus Energy

## Key messages

### Dagfinn Husjord

- Electrical ferries in Norway (51 ferry connections, **76 electrical ferries**)
- Electrical ferries in Vestland County (18 ferry connections, 21 ferry vessels, 6 contracts, 40 ferry docks, investment €66.4 million
    - Expected power consumption **80 GWH**/year
    - 60 % energy use reduction
    - 88 % greenhouse gas emission reduction
- Land infrastructure
    - **Grid upgrade, battery bank, charging tower**
    - Transmission **(22 kV, 400 V, 590 V, 690 V)**
    - Charging power (**1,750 kW)**
    - Investment: on-shore investment of 75 million €
        - 40 % from Vestland County



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- High-Speed Craft vessels (HSC)
    - First vessel on the water in 2026
    - HSC has the highest $CO_2$ emission to transport a person one kilometre (904 g)
    - Goal: reduce emissions by 85 % starting 2026
    - €150 million
- **Hybrid-Electrical** fishing vessel
    - **Fishing** without noise – developed by fisherman
    - 3,000 fishing boats over the next ten years
- Fully electrified **container ship** – battery pack **6.7 MWh**
- Skills and job roles due to electrification
    - New and close **collaboration** between electrical power suppliers and the transportation industry
        - Creating redundancy in all parts of the operations
    - **Engineers on board** have improved their **expertise in battery and hybrid operation**
        - From water cooling to air cooling
        - Increased knowledge and operational skills in monitoring control systems
            - Chief engineers get specific **training and, in case of errors, assistance from equipment suppliers**
        - Fire protection and safety – **temperature monitoring, thermal runaway protection**
- Lessons learned
    - Infrastructure must be planned more carefully and better
    - Challenges in the extension of the power grid – non-urban areas
    - More land area needed for technical houses – grid and charging facilities
    - Going from diesel to electric power – changing the flexibility (greater predictability)
- Overall
    - Significant investments (vessels and shores side), public strategy and policies for the long-term requirement are needed
    - Shoreside charging infrastructure
    - Greenhouse gasses reduction is substantial
    - Being a fast mover – has resulted in higher expenses

**Chris Kornet**

- Different types of vessels:
    - Dry cargo vessels – fully electric driven
    - Tankers – LNG generators
    - Push boats (pushers) – 50,000 tons of cargo
    - River cruisers – diesel and electric (big shore connection) – go for short periods on batteries (in the city)
        - The goal is to make emission-free cruisers


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- 8,000 waterway vessels in the Netherlands
- To be sustainable, a long battery life cycle is necessary
- The life cycle of the ship is **much longer** than truck
- 99 % of ships are recyclable
- Alternative fuels to electrification: compressed $H_2$, liquid $H_2$, amonia, methanol, bio-diesel
- Sustainable future
    - Lower lightships weights (implementation of future fuels and batteries) - (14 km with 200 kW power)
- Custom ships (depends on using): short distances = batteries; long distances = diesel/LNG
- Futureproof vessels
    - Battery systems on board, changeable batteries from ZES
    - The challenge is in **changing the batteries quickly**
- **Education** for students – **different types of fuel power** (batteries, $H_2$, LNG, diesel, Solar panels…nearly everything except ammonia)

*How to speed up the electrification?*

- Taxes will make the change bigger – but the extra cost for ordinary people
- Long term contracts

**Michiel Smit**

- The goal is to reduce **$CO_2$** and **$NO_X$** emissions, but also **noise emissions**
- New energy concepts for inland shipping – Zero Emission Services
    - **Exchangeable energy containers**
    - **Charging infrastructure** and **grid balancing**
    - Pay-per-use business models
- ZESpacks 2.0 – swappable Modular Energy Containers

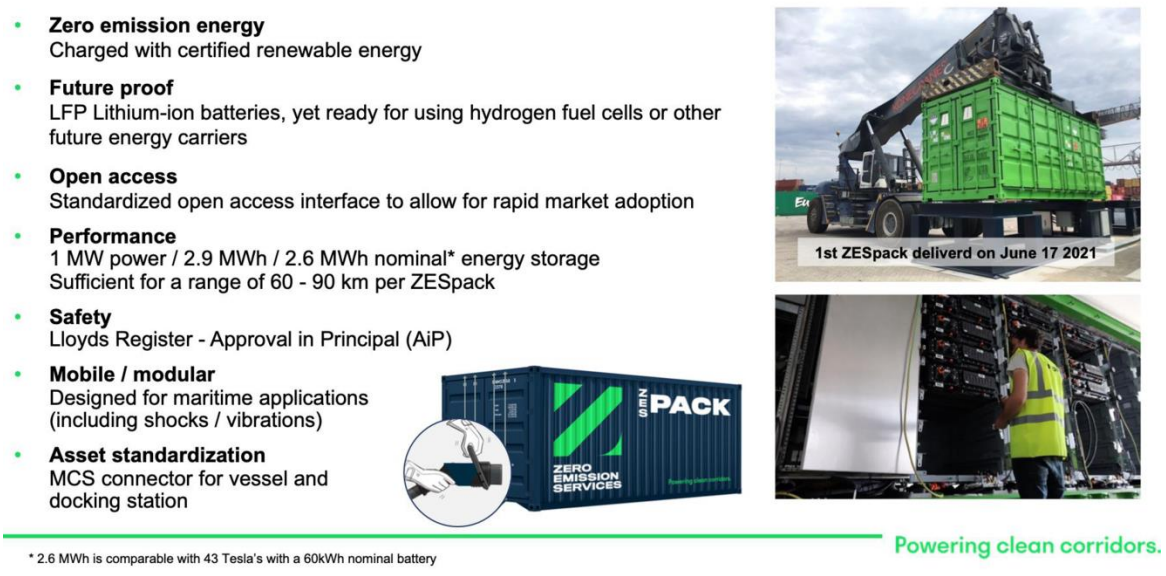


Figure 14: Example of the swappable modular containers



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- Docking station – first operational station in CCT Alpherium, Alphen a/d Rijn
    - Total area 15×25 m
    - Double charging 1 MW
    - 2× ZES Packs charge in 2.5 hours
    - Docking station 2.0 in development
- Energy hub opportunities
    - Locally produced, locally used
- High fuel and emission reduction (Jan-Nov 2022): 223 t $CO_2$ and 7 t $NO_x$
    - Use of 1 ZESPack on one way (2 packs on board for the way back)
    - The first number in the picture is the number of vessels, followed by the number of ZES battery packs and then the number of docking stations

**Josefin Klindt**

- EST-Floattech B. V.– developing and manufacturing proven DNV-certified **Li-NMC** modules for high energy and maritime power applications
    - Battery experts – 10 years, more than 200 projects, more than 50 MWh battery capacity installed (passenger vessels, ferries, yachts, coasters)
    - Customised containerised solutions
- Bella Bohemia – the first **fully electric** sightseeing vessel in Prague
    - 250 seats, 116 kWh battery, 25.09m length and 9.6m width
    - Silent and emission-free sailing – the main reason for building electric passenger boats
    - Prague boats operate a total fleet of 20 boats
- Need for cooperation – working together
    - Bring all the knowledge together to make the system run and to make the customers happy
- The challenge to **change the mindset** of the ship owners to go for fully electric or hybrid-powered vessels

**Frederik Thornell**

- Primary focus on high-speed vessels – highest pollution
- A lot of high-speed vessels across the world are to be replaced
- Beluga24: Emission-free power, Carbon Fiber construction (lightweight); waterjet propulsion
    - 50 % less energy than other traditional vessels
    - Aim for energy efficiency – **LTO batteries**
- The current vessel fleet is, on average, 40 years old and emits around 40,000 t of $CO_2$/per year
    - 50 % of the yearly emissions of the region
- 2024: New York water taxi

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## Key findings

- The advantages of electrified inland waterway vessels include a reduction in **$CO_2$** and **$NO_x$** emissions and other pollutants, as well as **noise** reduction
- **Tens of electrified** ferries have already been in operation in Norway
- Land infrastructure requires **grid upgrade, battery bank, charging** tower - transmission (22 kV, 400 V, 590 V, 690 V), charging power (**1,750 kW)**
- Hybrid-electrical fishing vessels allow for fishing without noise
- A fully electrified **container ship** can have a battery pack with a capacity of **6.7 MWh**
- Engineers on board have been improving their expertise in battery and hybrid operations - engineers get specific **training** and assistance from equipment suppliers in case of errors. **Fire protection** and **safety** are among the key topics, together with **temperature monitoring, thermal runaway protection**
- To be sustainable, a long battery life cycle is necessary - the life cycle of the ship is **much longer** than a truck, for example
- **Exchangeable battery packs** are one of the possible technological concepts - the challenge is in changing the batteries **quickly**

Job roles, skills and knowledge identified in the webinar

- **IT, cyber-security, programming skills**
- **Hands-on engineering and servicing skills**
- **Impact/lifecycles/circularity assessments**

Training needs identified in the webinar

- **Fire protection** and safety are among the key topics, together with **temperature monitoring, thermal runaway protection**
- **Education** for students shall include a combination of **different types** of fuel power (batteries, $H_2$, LNG, diesel, Solar panels…)

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# 7 Webinar Safe Recycling & Second Use of EV Batteries

*Agenda*

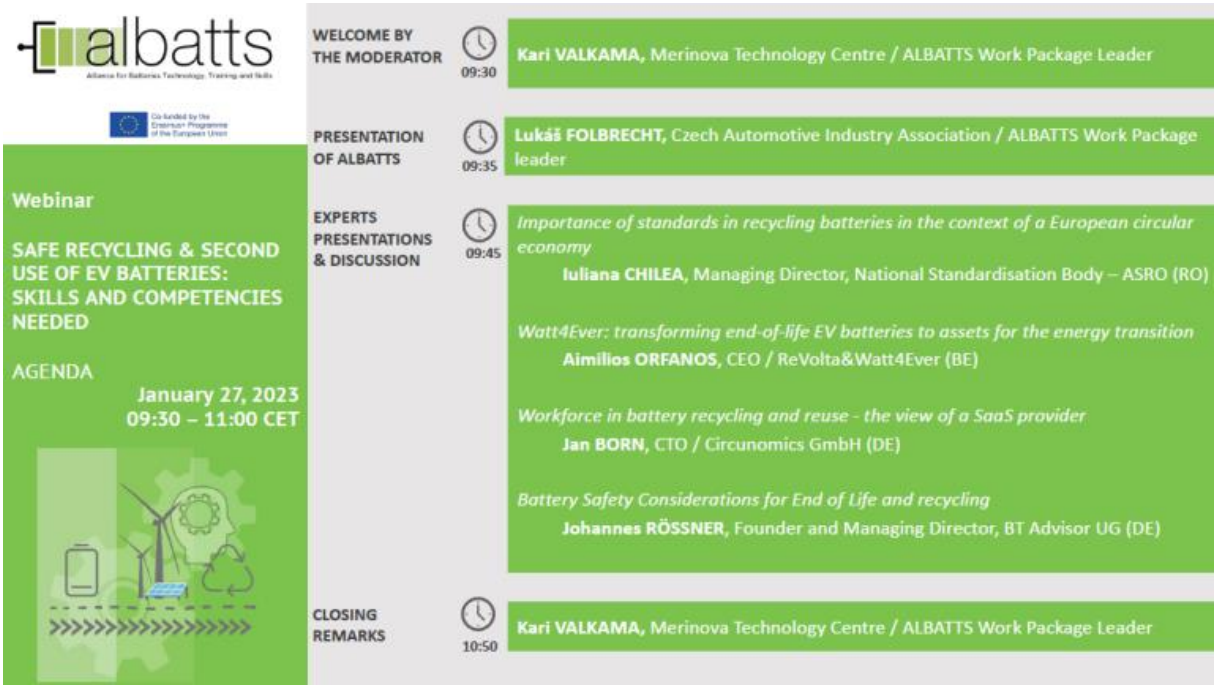


**Figure 15: Agenda of the webinar**

*Purpose of the workshop*

Promote the deliverables of the project that have been completed so far, collect valuable inputs from **independent specialists** and audiences and stimulate the registration of new stakeholders.

Properly managing the spent/defective EV batteries has become a concern for the stakeholders in the automotive sector, especially in the battery value chain. On the one hand, manufacturers must ensure that batteries fulfil the manufacturing standards for the power units **in new vehicles**. However, on the other hand, they must comply with the requirements associated with the remanufacturing, reuse and recycling capabilities.

Furthermore, to stimulate this transition prompted by the rapid proliferation of electrified vehicles, in December 2022, the EU Parliament and Council reached a provisional agreement on the "**EU Battery Regulation**" based EU Commission proposal (document COM/2020/798 final), confirmed in early 2023, to overhaul EU rules on batteries.


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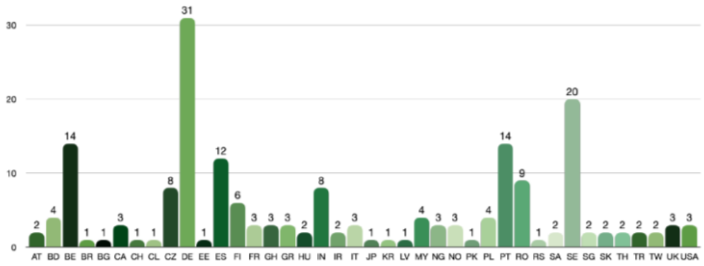
Once in force, this regulation will require new circular partnerships between battery manufacturers and recyclers. The agreed provisions will cover the **entire battery life cycle**, from design to end-of-life and apply to all types of batteries sold in the EU, including those for electric vehicles (EV) or the batteries providing power for the traction to other wheeled devices (such as electric scooters and bikes).

Through this regulation, EU regulation calls for OEMs to collect more than **70 % of EV batteries in 2030**. In addition, specific recycling requirements will also be introduced for the lithium, cobalt, copper, nickel, and lead content of batteries. Moreover, in this context, considering the rising demand for electrified vehicles and insecure sources, it is expected to turn battery recycling in Europe into a key lever in ensuring constant critical raw material streams, cost reduction and mitigation of risk around looming raw material supply constraints.

To implement an effective strategy to comply with the sustainability requirements and achieve an adequate digital and green transformation, the companies from the batteries value chain should focus on developing a **qualified workforce** through up-/reskilling.

*Registrations*



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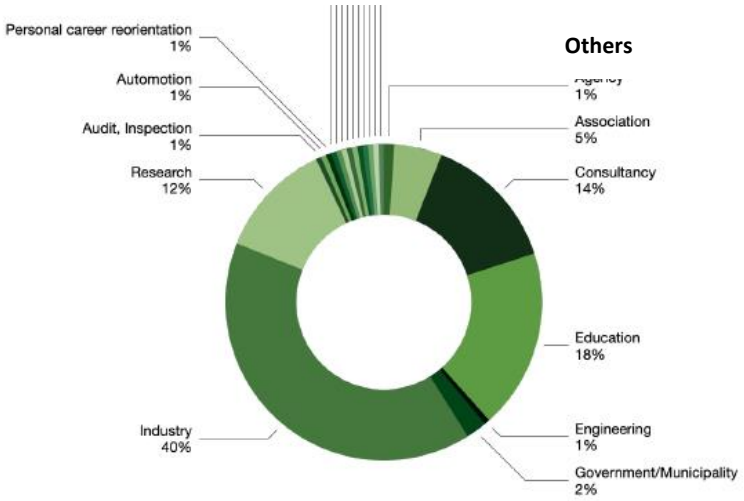


Figure 16: Number of registrations and their distribution by sector

The number of participants via the Webex online platform was **120**. On top of that, **17** viewers followed the event's live stream on Facebook. Others (**93** persons as of 8. 2. 2023) have so far accessed the recording on the ALBATTS website. The stream remains available there for further viewers.

Participants

*Moderator, speakers*


Figure 17: Moderator and speakers

*Moderator*

**Kari Valkama** is a project manager at Technology Centre Merinova in Vaasa, Finland. Merinova is the leader of the EnergyVaasa Cluster, which possesses the Gold Label of Cluster Management Excellence. Merinova is involved in various projects, programs and services regionally, nationally and globally. His expertise is in energy technology and business



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development. He holds a degree in Business Administration and has years of experience working with business and general development-related tasks in SME companies in the metal and cleantech industries.

*Speakers*

**Lukas Folbrecht** has been leading ALBATTS project WP5 – Intelligence in Mobile Battery Applications, which analyses the use of battery technologies and relevant job roles and skills in moving devices. His previous experience includes positions in SKODA AUTO, the Office of the Government of the Czech Republic and the media, as well as work and study experience in the US, the UK and Brussels. Lukas is also a secretary of the Czech E-mobility Platform and an e-mobility enthusiast.

**Iuliana Chilea** has been the General Director of the Romanian standardisation body - ASRO since 2017. She has been involved in the standardisation activity for over 15 years, actively participating in the technical and management structures of CEN and CENELEC – the European standardisation organisations, where she was nominated to lead various working groups focused on developing and reshaping the standardisation processes. Furthermore, as the Romanian delegate to the Committee on Standards from the European Commission, she is aware of all the trending activities related to regulations, directives, and standardisation mandates the EC is developing to implement its objectives for the European Market.

**Aimilios Orfanos** is an expert in energy flexibility and energy storage. He has ten years of experience in the industry, where he led innovative products in energy flexibility creation in companies like Elia and the Casino group. He is a leading expert in energy storage and demand response in Belgium, and in his role at Elia has led the opening of ancillary services to batteries. He is the founder and CEO of Watt4Ever and ReVolta.

**Johannes Roessner** is the founder and managing director of BT Advisor UG, which aims to improve the safety of battery handling. The customers are battery test labs, companies developing batteries, and any other company needing to handle batteries. In addition, BT Advisor UG helps to make the validation of batteries more efficient and thus contributes to



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developing safe and long-lasting batteries. Johannes Roessner has over ten years of experience in the battery industry. He worked at TÜV SÜD in Munich in a battery test laboratory with various functions and was in charge of all kinds of battery tests. This ranges from performance to environmental and abuse testing and from cell level to system level. In the last seven years, Johannes Roessner worked in Japan and China and was involved in the planning, construction, and operation of battery test labs there. In June 2022, he founded BT Advisor UG after returning from Asia. The experience from battery testing and lab operations now helps to better assess the risks of batteries and the effectiveness of means to minimise risks.

**Jan Born**

Co-Founder & CTO

Has MSc in Computer Science and more than 15 years of experience in digital business & transformation, most recently as CTO & MD of the tech company media man. Focus on the business value of technology & the automotive sector.

**Jenny Gaekel**

Human resources executive with over 20 years of expertise in HR, Operation, business strategy, international relocation specialist, sales, and marketing. Currently, working as Human Resources Business Partner for Circunomics GmbH, focused on talent acquisition, retention, and motivation solutions to harness a full-power and valuable team. In addition, she is dedicated to creating a culture that promotes continuous business growth by cultivating customer loyalty and motivating employees to realise their full potential with a strong belief in the power of positive thinking in the employees and helping them be their best every day.

## Key messages

**Kari Valkama**

- Rising demand for **electrified vehicles** and **insecure sources** are expected to turn battery recycling in Europe into a critical lever in ensuring constant streams, cost reduction and mitigation of risk around looming raw material supply constraints.



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- The companies acting in EV battery **recycling and second life** need to develop a relevant strategy that would enable their organisation to handle the upcoming future technological developments and comply with the sustainability requirements. To implement the strategy effectively and achieve an adequate **digital and green transformation**, their main focus should be developing a multi-skilled workforce through up-/reskilling.

**Lukáš Folbrecht**

- The European battery industry is **lagging behind** Asia, China and other regions, and as we would like to keep up with them, therefore we need skilled personnel.
- The objective stated above is the main task of the colleagues from WP6 that will address what needs to be done regarding **training, reskilling and upskilling**, update the curricula, pilot projects, pilot training programs and materials and "train the trainer" guidelines.

**Iuliana Chilea**

- **Standards** bridge the gap between the legal framework and internal voluntary industry standards. At the European level, harmonised standards support EU legislation by complementing and specifying the **technicalities of the legal requirements**, compliance with the standards, and granting products the presumption of conformity with the relevant EU legislation, thus allowing manufacturers to access the EU market.
- Currently, there is **no particular standard** concerning the recycling of EV batteries, only a draft.

**Aimillos Orfanos**

- The hordes of spent/defective propulsion batteries must be dealt with responsibly and adequately for two primary considerations: to successfully close the **circular economy** loop and **support the grid** with sustainable, affordable and safe storage capacities, and the stakeholders need to build a system which would be capable of preparing the necessary workforce to achieve the objectives stated above.



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- The environmental gains from second-life batteries add further importance to the circular economy principle: for every 100 kWh worth of reused battery, the society **spares 11 t $CO_2$ grey emissions**, 100 t $CO_2$ by offsetting renewable energy over ten years, 1 tonne of hazardous materials and the extraction of 555 kg of cobalt.

**Jenny Geakel, on behalf of Jan Born**

- Today's propulsion batteries are responsible for 50 % of the cost of an electric vehicle or energy storage and almost 70 % of its lifecycle carbon emissions. The most powerful lever to reduce the carbon footprint and increase the **profitability of a battery** is a second life/use.
- To make this a reality, OEMs and energy companies need an infrastructure to manage millions of used batteries, as they currently have no partner to **transport, test, dismantle, remanufacture, and recycle** tens of thousands of used batteries.

**Johannes Roessner**

- Old/spent batteries are particularly **unstable** as a result of a plethora of conditions and severe hazards that may stem from malfunctions and/or mishandling;
- Technicians dealing with EV batteries along the value chain links involving **removal from the vehicle, remanufacturing, second life, dismantling and recycling** must be thoroughly trained to ensure hazard-free operation.

## Key findings

- **Recycling capacities** need to be expanded as the current recycling infrastructure capacities are unsuitable for the estimated volume of spent batteries.
- There is a severe shortage of **courses and training** in battery recycling, such as training on **norms & standards**.

Job roles, skills and knowledge

- **Automated dismantling**
- **SoH estimation methods**
- **Design for recycling & reuse**

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- **New generation BMS's & EMS's**
- **Battery diagnostics and repair**
- **State of Health estimation**
- **Battery dismantling**
- **New system design/assembly**
- **Machine Learning Architect**
- **Data Engineer/Manager/Leader/Scientist**
- **Analyst**
- **Lab testing, design, and supervision of data quality**
- **Fast, cheap, and accurate SoH, SoC estimation from the field, historical, and lab data**
- **Anomaly detection and batteries security**
- **Developing AI and physics-based models**
- **Capturing non-linearities**
- **Optimising the parameters, model validation, and testing**
- **Analysing, cleaning, exploring and getting insight from data and designing impactful KPIs**
- **Design resilient and scalable architecture and infrastructure**
- **Developing Data Pipelines**
- **Cybersecurity and data privacy**
- **Frontend-Development**
- **Backend-Development**
- **Software-Architects**
- **DevOps**
- **Battery pack disassembly**

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