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Alliance for Batteries Technology, Training and Skills

2019-2023

Analysis of Future Needs – Release 3

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Deliverable D3.11 Analysis of Future Needs - Release 3

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Executive Summary

Public webinars and interviews were used to discuss the EU battery sector skills and competence needs with the sectoral stakeholders – speakers and the audience. The aim of the events that were organised by the project ALBATTS consortium was to gather skills needs and have a debate on the sector development in **four interviews**: (1) two interviews on **future battery technologies**; (2) second life bus batteries in BESS residential applications; (3) future geopolithical challenges in the source of raw materials and the battery value-chain; and in **eight workshop** events with the following themes: (1) electrification of the aviation sector; (2) electrification of heavy-duty vehicles; (3) electrification of inland waterways; (4) safe recycling and second use of EV batteries; (5) Lithium – European sourcing and skills; (6) BMS and control systems; (7) Skills transition; and (8) EV safety webinar.

The document outlines trends, job roles, skills/competences and knowledge, education, training offer, and re- and up-skilling delivery for each workshop event if the information was available.

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Introduction

This document summarises key findings, data and needs gathered during the third iteration of ALBATTS interviews, workshops and other events held in late 2022 and 2023. Overall, **four interviews**[1] were held, with:

1) Tomas Kazda, Assoc. Professor at Department of Electrical and Electronic Technology at Brno University of Technology – "*FUTURE BATTERY TECHNOLOGY: Job roles, skills and knowledge*";
2) Noshin Omar, Founder and CEO at Avesta Battery and Energy Engineering at Brno University of Technology – "*FUTURE BATTERY TECHNOLOGY: Job roles, skills and knowledge*";
3) Ylva Olofsson, System Design Engineer and Project Manager at Volvo GTT – "*Second life Bus Batteries in BESS Residential Applications: Job Roles, Skills and Competences*"; and
4) Daniel Cios, Policy officer – Raw Materials at DG Grow, European Commission - "*Future geopolitical challenges in the source of raw materials and the battery value-chain*".

Overall, **eight workshops**[1, 2] were held, titled:

1) Electrification of the Aviation Sector and Future Qualifications Needed;
2) Electrification of Heavy-duty Vehicles: What skills and competencies will be needed;
3) Electrification of Inland Waterways and Future Qualifications Needed;
4) Safe Recycling and Second Use of EV Batteries: Skills and Competencies Needed;
5) Lithium Mining and Extraction: European Sourcing and Skills
6) Battery Management Systems (BMS) and Control Systems: Job Roles, Skills and Competencies
7) Skills Transition in the Battery Industry: Training People from other Industries
8) Safety Aspects of EV Manufacturing, Use, Maintenance, Repair and Disposal

[1] ALBATTS report D4.9, available at https://www.project-albatts.eu/Media/Publications/89/Publications_89_20230303_133552.pdf (last accessed on 23/05/2023)
[2] ALBATTS report D5.9, available at https://www.project-albatts.eu/Media/Publications/88/Publications_88_20230228_125942.pdf (last accessed on (23/05/2023)

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Each event is is described together with findings concerning skills, education/training, and job role needs connected to the battery ecosystem development and related trends. These findings will be further used in the context of other findings of project ALBATTS, especially the Sectoral Skills Strategy update in November 2023.

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List of Abbreviations

ALBATTS	…	Alliance for Batteries Technology, Training and Skills
ADAS	…	Advanced Driver-Assistance Systems
ASA	…	Automotive Skills Alliance
BES	…	Battery Energy Storage
BESS	…	Battery Energy Storage System
BESS	…	Battery Energy Storage System
BEV	…	Battery Electric Vehicle
BMS	…	Battery Management System
CNG	…	Compressed Natural Gas
CO2	…	Carbon Dioxide
CRM	…	Critical Raw Materials
CTIF	…	International Technical Committee for the Prevention and Extinction of Fire
DC	…	Direct Current (electricity)
ELV	…	End-of-Life Vehicles
EU	…	European Union
EV	…	Electric Vehicle
HR	…	Human Resources
ICE	…	Internal Combustion Engine
ICEV	…	Internal Combustion Engine Vehicle
ICT	…	Information and Communication Technology
IP	…	Intelectual Property
IT	…	Information Technology
LCA	…	Lifecycle Assessment
LLL	…	Life-Long Learning
LNG	…	Liquified Natural Gas
OEM	…	Original Equipment Manufacturer
PHEV	…	Plug-in Hybrid Vehicle
R&D	…	Research and Development
STEM	…	Science, Technology, Engineering, and Mathematics
VET	…	Vocational Education and Training
VET	…	Vocational Education and Training
VR	…	Virtual Reality

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1 Future Battery Technology – Automotive Industry and Grid

The purpose of the held interview was 1) 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 and 2) to explore the trends in battery-relevant Research & Development areas and relevant job roles, skills and knowledge needs.

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.

1.1 KEY HIGHLIGHTS AND NEEDS

This section provides a summary of key aspects that were discussed during the interview.

- 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.
- Electrical engineering and mechanical engineering was highlighted.

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2 Future Battery Technology – Battery Production and Recycling

The purpose of the held interview was 1) to provide a discussion about the current and the new trends in battery technologies and the production and recycling of batteries and 2) to explore the trends in battery-relevant start-up and Research & Development areas and relevant job roles, skills and knowledge needs.

The number of participants via 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.

2.1 KEY HIGHLIGHTS AND NEEDS

This section provides a summary of key aspects that were discussed during the interview.

- 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
- Modelling and thermal management was highlighted
- Workforce needed in the context of the topics: chemical, electrochemical, electrical or process engineers together with cell designers.

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3 Second Life Bus Batteries in BESS Residential Applications

The purpose of the held interview was to explore the use of second-life bus batteries in stationary residential applications and which job roles, skills and competencies are required.

The number of participants via Webex online platform was **22;** 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.

3.1 KEY HIGHLIGHTS AND NEEDS

This section provides a summary of key aspects that were discussed during the interview.

- 2nd life BESS use majorly the same skills and competencies as a 1st life BESS with a focus
- on engineering and project management skills;
- Creativity is key;
- The EV market is changing very rapidly – There are a lot of opportunities in different market sectors such as recycling and 2nd use of batteries;
- An opportunity for EV (car, buses, etc.) batteries is to be re-used in a stationary BESS to increase their lifespan;
- It is needed to create the business case for 2nd life batteries for the area to thrive. Right now the efforts are in R&D to make the systems viable – maximizing the use of the battery before recycling;
- Fundamental interest in seeing a change in society is as important as having the right skills and competencies;
- **Job roles, technical skills and competencies identified**: Laboratory management, electrical safety for fire hazards or fire brigades (fire insulation rooms, heat, smoke and gas detectors, external ventilation), battery safety (standards, fire standards, chemistry, battery reactions), mechanical safety, software safety (alarms and signalling), battery parameters evaluation, software algorithms, cabling and connections (electrical engineer), Thermal management (thermal engineers, cooling experts), ageing testing (PhD with knowledge in chemistry and battery reactions. Testing the batteries for ageing)

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project management, strategic development, logistics, LCA studies, Legal aspects (agreements between parties, IP rights), knowledge on the electricity market, sales;

- **Soft Skills identified**: interest in the topic, creativity, bravery in making decisions, leadership, mindset towards the goal, interest in engaging in conversation about batteries.

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4 Future geopolitical challenges in the source of raw materials and the battery value-chain

The purpose of the held interview was to comprehensively examine the potential ramifications of the ongoing conflict on the supply of raw materials for the battery industry. Furthermore, the focus was on identifying the job roles, skills, and competencies that would be vital to alleviate the challenges created by the ongoing war.

The number of viewers was **42** following the event's live stream. Viewers were following the live stream also on ALBATTS's Facebook profile. At the time of the writing of the report it counts **25** views. The stream remains available on the ALBATTS website and Facebook profile.

4.1 KEY HIGHLIGHTS AND NEEDS

This section provides a summary of key aspects that were discussed during the interview.

- Materials at risk other than NG: Nickel sourced from Russia, refined in Finland; Platinum group metals (Palladium) sourced from Russia, around 20 CRMs are sourced in Ukraine, 60% of Titanium reserves are in Ukraine, cobalt, lithium and one of the biggest deposits of Natural Graphite are in Ukraine, big quality minerals for ceramics.
- Europe's context (Green Goals, invasion of Ukraine, disruption in material supply) led to EU to develop (5) strategies to guarantee the supply of raw materials.
- The battery industry hardly will achieve 100% independence from sourcing outside Europe. However, Lithium mining and refining is gathering investors' interest, although it is a very long process.
- Europe is not very rich in raw materials (CRM specifically). But the global demand will rise in the future.
- EU is developing criteria and principles to define the sustainability of sourcing raw materials (social, economic, and environmental).
- Horizon 2020 has a long list of calls for R&D projects related to sourcing, refining, processing, substituting, reusing, recycling, recovery, and policy support of raw materials.
- Attraction of students to raw materials relevant courses is crucial and it faces high competition with other courses (IT for example).

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- Forecasting political risks, the demand for materials and technology, sourcing from primary and secondary materials, finding substitutes and diversifying the source of the materials are the strategies to mitigate future materials shortage.
- China is the main supplier of many raw materials. It would be very hard to have independence. The faster solution is to have more diversified sourcing from other countries.
- Drivers of change found: disruption in energy supply; high energy prices; shortages in supplies of materials; disturbance in the supply of raw materials due to war; investors are interested in sourcing and refining battery materials; EU is investing in R&D to prevent the shortage of battery materials; technical people are joining the meetings and events for decision-making policies, not only investors.

Job roles, skills, and knowledge

- Investors for funding mining and refining of materials
- R&D technicians and developers
- Policymakers
- Experts in the industrial process, operating manufacturing plants, operating machines, and optimization of the process
- Geology, metallurgy, mining engineering, material sciences
- Forecasting demand for materials and technology

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5 Electrification of the Aviation Sector and Future Qualifications Needed

The purpose of the webinar was 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.

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.

5.1 KEY HIGHLIGHTS AND NEEDS

Key highlights and needs are highlighted in this section.

- 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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6 Electrification of Heavy-duty Vehicles: What skills and competencies will be needed

The purpose of the webinar was 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.

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.

6.1 KEY HIGHLIGHTS AND NEEDS

Key highlights and needs are highlighted in this section.

- 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 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**
- **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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7 Electrification of Inland Waterways and Future Qualifications Needed

The purpose of the webinar was to learn more about the topic and the skills and competencies needed to achieve lower and zero emissions in inland waterways operations.

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.

7.1 KEY HIGHLIGHTS AND NEEDS

Key highlights and needs are highlighted in this section.

- 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

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- 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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8 Safe Recycling & Second Use of EV Batteries

The purpose of the webinar was to learn more about the topic and the skills and competencies needed within the safe recycling and second use of EV batteries and connected regulation.

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.

8.1 KEY HIGHLIGHTS AND NEEDS

Key highlights and needs are highlighted in this section.

- **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, especially training on **norms & standards**.

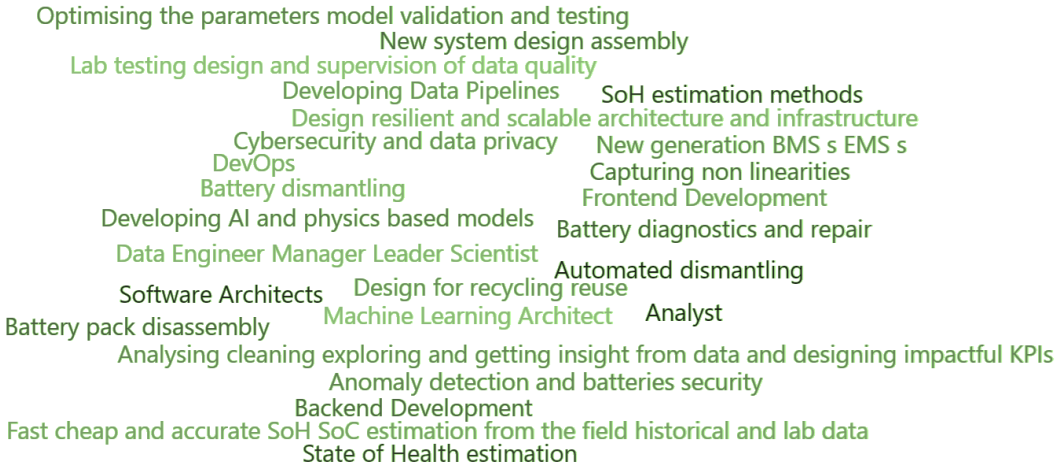

Figure 1: Identified Job Roles and Competences

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9 Lithium Mining and Extraction: European Sourcing and Skills

The purpose of the webinar was to to gather skills and competence information from the first stage of the battery value chain, minerals, and processing, by looking into lithium mining and extraction. The questions we wanted to address in the event included:

- Where are the lithium deposits?
- How is lithium mined and extracted?
- Can it be recycled?
- And naturally, what job roles, skills and competencies are needed?

The number of viewers was **73** on the Webex platform while there were also viewers following the event's live stream on Facebook. The recording is available on the ALBATTS website.

9.1 KEY HIGHLIGHTS AND NEEDS

Key highlights and needs are highlighted in this section.

- We are dependent on lithium coming from abroad.
- The demand for battery raw materials, incl. lithium will increase significantly by 2050.
- Europe is likely to confront a huge supply gap in the coming years.
- The global competition for battery-grade raw materials is a potential security issue.
- Actions are needed to strengthen EU production and diversify supply sources.
- Communicating with the public is important due to social acceptance issues.
- Expertise & skills need to be developed (re-/upskilling among the EC priorities).
- Lithium's exploration, mining and processing do not differ from other minerals/metals.
- We are moving from conventional to more digitalized and sophisticated mining.
- Introduction of technology to mining brings high demands for skills and know-how.
- The availability of employees is not high in Europe which is a challenge at the moment.
- Lithium has high electrical conductivity and is thus excellent material for batteries.
- The sources: brines, hard-rocks and other (seawater, hectorite and geothermal brines)
- 527 European hard-rock deposits and 182 geothermal brine occurrences identified.
- Lithium is a strategic, critical metal. Its prices have increased significantly since 2020.

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- Lithium battery's biggest estimated future use area, by far, is EVs.
- The main steps in the metallurgical treatment, from ore to lithium commodity include the acid process (the most common), autoclave carbonation and alkaline roasting.
- The main environmental concerns include waste-water management in hydrometallurgical operations and gas emissions in thermal treatment.
- Recycling batteries provide critical materials crucial for the green transition, reduces the need for primary resources and reliance on imports, and is essential in dealing with environmental concerns.
- Battery Regulation has been proposed for clear and harmonized rules to make recycling profitable and mandatory.
- Collection of batteries is an essential element enabling recycling.
- Safe handling and processing are important with battery collection and storage. Labelling required recycling-related categorizing.

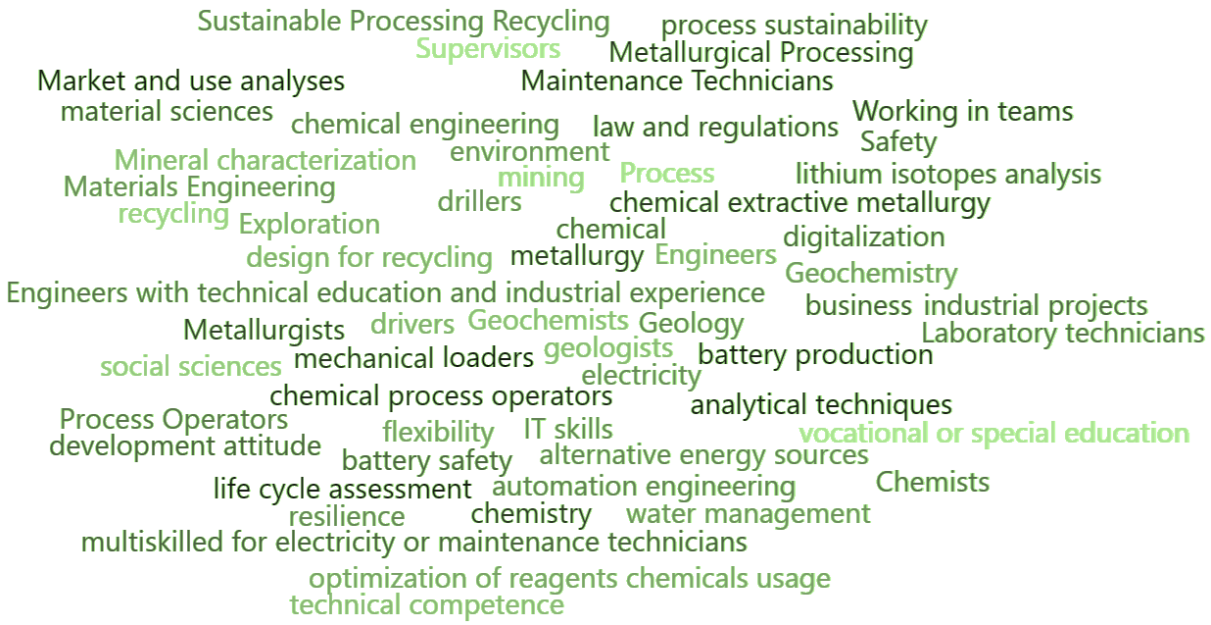

Figure 2: Job Roles and Competence Identified During the Webinar

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10 Battery Management Systems (BMS) and Control Systems: Job Roles, Skills and Competencies

The purpose of the webinar was to focus on the role of BMS and Control Systems in Stationary Energy Storage Systems, in EV Charging Stations and in Electric Vehicles

The number of viewers was **42**. The rest have accessed the recording on the ALBATTS website. Viewers were following the live stream also on ALBATTS's Facebook profile.

10.1 KEY HIGHLIGHTS AND NEEDS

Key highlights and needs are highlighted in this section.

- The most important aspect of battery management systems is their safety functionality. Therefore, proper skills are needed and every speakers introduced their positions and requirements for the level of expertise on each assignment related to the completion of the BMS systems.
- Apart from the complexity of these systems they are very flexible for new technologies adopted in the battery field. The hardware is not changing as often as the software as it was stated by our speakers.
- Important finding was also relevant to the changes in the automotive industry where old batteries are moving to the second-life market where the BMS plays a key role to maintain the overall safety of the battery modules. A suggestion was made towards high usability of second-life batteries in the solar storage systems.

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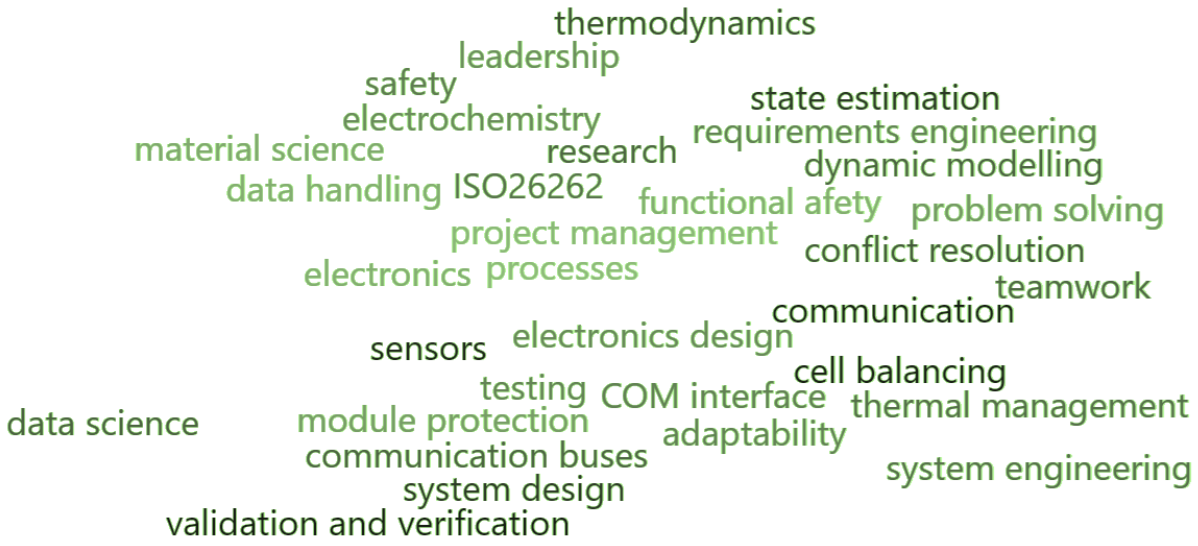

Figure 3: Job Roles and Competence Identified during the Webinar

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11 Skills Transition in the Battery Industry: Training People from other Industries

The purpose of the webinar was to gain understanding of the skills transition processes designed for blue- and white-collar level employees. We wanted to learn about for example, the possibilities and challenges encountered.

The number of viewers was **54**. Viewers were following the live stream also on ALBATTS's Facebook profile. The recording of the event is available on the ALBATTS website.

11.1 KEY HIGHLIGHTS AND NEEDS

Key highlights and needs are highlighted in this section.

- High demand for manpower for battery sector and 85% of them are on the VET level.
- Constant change of the skills/competences or knowledge needs during one's career.
- Up- & reskilling workforce from descending sectors
- Need for new training courses, new ways of training courses delivery and offer
- By 2030 2.4 million jobs will require partly high retraining, 1.6 million persons need re-skilling within the same job profile and 610,000 must change their job profiles slightly. Just 225,000 persons need radical retraining into different job profiles and industries.
- Northvolt establishing their plant in Skellefteå had a major impact on the area.
- Reacting to such a major change required for example in Skellefteå's case understanding how it affects all the sectors and companies. Consequently, the education providers have to be able to look into the big picture.
- Automation Operator Programme was the first one based on a draft from Northvolt.
- 15 programmes at VUX requested by and supporting Northvolt and others in the area.
- Getting students with public application, relocation efforts and upskilling programmes.
- VUX combines successfully practise to theory in the education programmes.
- People with very different backgrounds can be re-/upskilled (for example from a grocery store's customer service to an operator via automation operator programme)
- Many participate the education programmes of VUX to change their careers.

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- Attracting women to the technical education by VUX has been achieved by communicating more about the chance to be a part of the transformation and the process of doing something for the environment and less about technologies.
- Understanding the Importance of change management and how challenging it can be.
- Importance of dealing with opposition during the change process
- Electrification of vehicles is leaving fossil fuel specialists without work.
- It is important to meet the hopes, fears and needs of the participants taking part to up-/reskilling courses and how are in the middle of the transition.
- Try to make them curious, as curious people are paying attention and when you pay attention you understand what needs to be done.
- Making people to be more eager to learn new things by making them to realise that while much is new most remain the same in the case of case ICV vs EV.
- With EVs understanding chemistry and physics required.
- In their E-mobility courses they target questions such as what is happening or why is it happening. However, the most relevant question is "What's in it for me?".
- It is important to have the flexibility to change the curricula based on the feedback from the students and the companies.
- Lack of trainers and teachers is a challenge for them. Teachers who can make their students to be interested in electrification are needed on every level.
- There will be jobs in the future that do not currently exist.

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12 Safety Aspects of EV Manufacturing, Use, Maintenance, Repair and Disposal

The purpose of the webinar was to learn more about the **safety aspects** of electric vehicles throughout their lifespan, promote and verify relevant ALBATTS project findings and stimulate the registration of new stakeholders to the project.

The number of participants via the Webex online platform was **81;** other viewers followed the event's live stream on **Facebook** or have been accessing the recording on the **ALBATTS website**. The stream remains available there for further viewers.

12.1 KEY HIGHLIGHTS AND NEEDS

Key highlights and needs are highlighted in this section.

New technology – Challenge or threat?

- Dangerous smoke while the battery is burning, the problem with reignition of batteries
- Need to recognize the propulsion/source of fire – LNG or CNG, batteries…
    - Different behaviour of fires (batteries burn differently than CNG or LNG)
    - **Training of firefighters** for special types of fires
    - Special stickers on public cars (buses, infrastructure…), to know the fuel (Diesel, petrol, CNG, LNG, electric…)
        - Easier to recognize the source of fire
- Legislations: CTIF webpage (ctif.org)
    - Gathering and sharing useful materials
    - Topic not coordinated at EU level - countries have their own legislation
- Special features of electric car fires from the point of view of firefighters
    - Lithium + water produces combustible hydrogen
    - Dangerous mission for firefighters – breathing apparatus needed
        - Last for about 20 minutes – firefighting the electric vehicle takes longer time – need to change oxygen bottles
    - Ventilation of fire gasses is essential
- Solutions/innovations

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  - Electric/Hybrid fire blanket – problem with different quality, age of blanket
  - Container to put the car in
    - Number of containers is rising – easy way to put out the fire (submerge the car in water and leave it there for as long as it takes to kill the fire for good)
    - They (as CTIF) cannot recommend to all firefighters to purchase the container
  - Renault vehicles fireman access
    - Enabling pouring/funnelling the water from hose directly into the battery pack
    - QR codes on the cars with instructions for firefighters – easier manipulation, extinguishing the fire, evacuating people…
- Problem of other models – impossible to put water inside the battery pack – COBRA system a possible solution for some EV models
- Innovation from Finland – for ships and parking houses
  - Portable pool, which can be assembled next to the burning car to prevent tow truck to catch fire/burn alongside the ignited EV
- Sprinklers cannot extinguish the fire of EV but provide cooling
- All EV fires are not caused by thermal runaway
- EURO Rescue app
  - CTIF collaboration with EuroNCAP
  - In this app, you can see X-Ray and instructions on how to deal with your car

Upskilling and reskilling of the workforce for safe automotive battery development

- Competition for talent – battery development projects are complex
  - Job roles needed for battery development projects - **electrical engineers, mechanical engineers, electro-chemical engineers, test field engineers, computer scientists**
  - Li-ion battery knowledge is needed to some extent for all engineers
    - Not part of typical studies
  - **Electro-chemists** as “Glue” between technical disciplines. If they are not present - lack of a common language in technical meetings

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- Automotive battery development is typical with separated teams
    - **Battery cell development, battery module/pack development, simulations, BMS, test field engineers…**
    - In every team, there are people responsible for safety on certain levels
- Battery education is challenging
    - Need for a large number of educated people
    - Limited number of post-graduate courses
- Battery Education must be flexible – it needs to be individual to be as effective as possible
    - Companies want to skill new talent but also upskill and reskill personnel
    - **Reskilling** – from ICE to Li-ion battery tech, from oil and gas to Li-ion battery technology
    - **Upskilling** – **Electrical engineer**, **mechanical engineer**, **project managers**
        - All of them need additional battery education
    - From university into consultancies within **Li-ion battery development**; **Li-ion battery testing** or **Li-ion battery production**
    - Flexible Li-ion battery program:
        - Covers basics of electrical engineering and electro-chemistry
        - Covers relevant advanced topics
- Battery education program (3 modules)
    - General overview of the technology, cell and system design
        - Operational principles, voltage under load, ageing, heat build-up, BMS and measuring
    - Industrial testing – electrical tests, safety tests, tricks and mistakes
    - Safety consideration of Li-ion batteries
- Small courses – 15 people maximum, to have space, can ask questions…

ISO 26262 – The Functional safety norm and Automotive battery systems

- Every cell has its own characteristic behaviour
    - Depends on the manufacturer (Northvolt, Samsung, CATL…)
    - Need for temperature control of every cell in the battery pack
    - Size, voltage, loading capacity…

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  - Characteristic measurements and curves
- Derivation of Safety Goals and **ASIL (Automotive Safety Integrity Level – defined by ISO26262)**
- Safety goals – what to avoid
  - Avoid battery overheating, thermal runaway, cell outgassing, battery explosion, electric shock, immediate loss of power leading, battery overcurrent
  - Each of safety goal has its own ASIL
- Safety design patterns:
  - ASIL D: 10 Fit, 99% DC for SPF
  - ASIL C: 100 Fit, 97% DC for DPF
  - ASIL B: 100 Fit, 90% DC
  - ASIL A: no targets (Daimler sets e.g. 1000 Fit)

Safety aspects in battery testing activities

- Batteries are very safe – you don't worry about the explosion of a fuel tank
  - Batteries are dangerous only in specific cases – overcharging, damage
- Safety testing – need to expect that fire/explosion can be an outcome
  - Used to extreme events – risk assessments on every test
    - Inform the people involved in testing, meetings, possible hazards…
- Electrical **safety**
  - Never 100% safe – risk assessment determines which measures must be taken
    - Need to train people to **high voltage testing**
  - Training and knowledge about consequences
    - Lack of good training
    - Problem with practical **training for technicians - measuring the parameters of battery packs**
    - Classic electrician (230 V AC) cannot deal with battery packs – upskilling necessary
  - Right tools and equipment
    - Safety equipment – at the beginning, look like an astronaut (many layers of standard safety equipment aren't good enough)

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        - Important to find the right level of safety equipment – too many pieces of equipment reduce precision (in thick gloves, it is hard to manipulate with small tools and parts…you can drop some tool and cause a short circuit)
    - Markings, separation, surveillance
- Roles: people working with the battery must have the required **skills through proper training**
    - Other workers in the area of batteries, offices, mechanics
    - Different working zones
    - Legal perspective and safety perspective
- Lock the doors while testing, don't leave opened battery pack unattended/unsupervised
- Problem with tunnels/overpasses – busses can get stuck in those areas
    - Signs, laser measurements, light indication…
- **Battery safety testing**

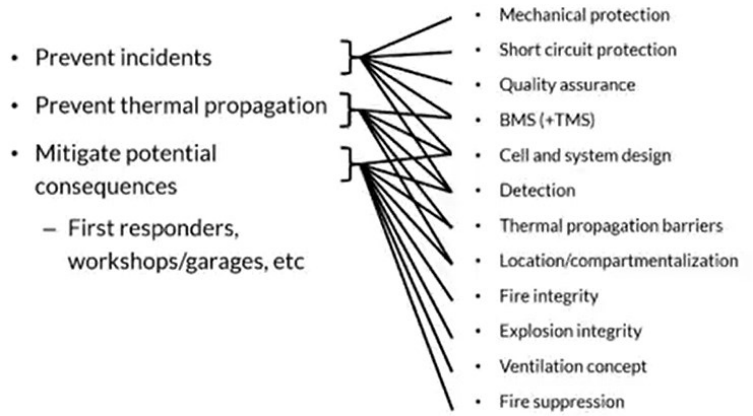

Figure 4: Battery Safety Testing Diagram

- EV fire myths
    - EV fires more common than ICE fires – No, the opposite;
    - Larger fire or more intense – No (same);
    - Can the fire be extinguished – Yes, but more difficult, it needs new tactics and methods;
    - Is the smoke more dangerous – No, not really (still dangerous).

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