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Alliance for Batteries Technology, Training and Skills

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Electric Vehicles
and Other Electric Means of Transport:
Job Roles and Qualifications Needed

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List of Abbreviations

AC	Alternating Current
AFIR	Alternative Fuels Infrastructure Regulation
AI	Artificial Intelligence
BEV	Battery Electric Vehicle
BMS	Battery Management System
CO_2	Carbon Dioxide
DC	Direct Current
EMC	Electro Magnetic Compatibility
EMS	Energy Management System
EPBD	Energy Performance of Buildings Directive
ESG	Environmental, Social and Governance
ETS	Emissions Trading System
EU	European Union
EV	Electric Vehicle
EVSE	Electric Vehicle Service Equipment
GEVSE	Grid and Electric Vehicle Supply Equipment
HDV	Heavy-Duty Vehicles
HW	Hardware
ICE	Internal Combustion Engine
KPI	Key Performance Indicator
LNG	Liquified Natural Gas
MCS	Megawatt Charging System
NMC	Lithium Nickel Manganese Cobalt Oxide
NO_x	Nitrogen Oxide
R&D	Research and Development
SoC	State of Charge
SoH	State of Health
SO_x	Sulphur Oxide
SW	Software
TCOs	Total Costs of Ownership
V2X	Vehicle-to-Everything
VVR	Vehicle-to-Vehicle Recharging

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1 Executive Summary

The ongoing "batterisation" of transport in the EU has mainly been driven by **EU emission reduction regulation** together with improvements in **performance** and **price** decrease of lithium-ion batteries. As a result of regulatory pressure and technological development, new business opportunities are opening in Europe, and new job roles, skills, and qualification backgrounds are needed to seize the opportunities.

The segments of electric **passenger cars, motorbikes, mopeds and bikes** have been overtaking some of the biggest challenges, and mass production has been launched. Nevertheless, for many EU car makers, achieving a positive business case remains a challenge, and they are often subsidising EV sales with profits from ICE vehicles. Competencies and qualifications in areas such as Battery pack manufacturing, Battery Management System (BMS), but also in servicing of the high voltage systems and battery diagnostics, for example, are being developed.

Other transport segments have not yet reached this level of technological and market maturity. The electric **trucks segment**, for example, still has a long way to go to find economically acceptable solutions that can meet the demands of the customers in the area of costs, distance reached and reliability. The **urban** and **regional transport** with short and middle distances seem much closer to market readiness than the long-haul segment.

Nevertheless, there are strong **drivers** of electrification of the commercial and heavy-duty vehicle segment in place, such as the currently revised CO_2 regulation, the Clean Vehicle Directive, ESG policies and the Alternative Fuels Infrastructure Regulation (AFIR), so solutions will need to be found both on the side of the vehicle and the charging infrastructure.

Job roles, skills and qualifications needed for the commercial and heavy-duty segment are similar to those needed for passenger cars. Nevertheless, there are some **sector specifics** – higher mass and capacity of batteries, higher charging powers, the importance of **depot charging**, innovative solutions such as **wireless** or **pantograph** charging to top up the energy

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while the vehicle is not moving (for example, at a bus stop or in the case o truck - when up/unloading the goods at the customer).

One of the reasons for the higher costs of vehicles is that EU companies have been focusing on ICE technologies for many years, while Asian companies, in particular, have invested in batteries and **taken the lead** in lithium-ion technology. As a result, the vast majority of the batteries used in European vehicles, making around **half of their value**, are now produced by Asian manufacturers in Europe or imported, which is reflected in their increased price and more complicated business case.

With **domestic producers** building gigafactories across the continent that are European or at least built in joint ventures with foreign partners, the economy of the whole battery business can be expected to improve. Moreover, researchers and developers might help the EU become competitive in new battery technologies, such as advanced lithium-ion, solid-state, or sodium-ion technologies.

Not only the production but also the **services** around electric vehicles will provide significant business **opportunities.** Domestic, corporate and public **charging infrastructure** will need to be designed, manufactured (HW+SW), deployed, operated, maintained, serviced, and upgraded, requiring Electrical Engineers and Technicans, Hardware and Software Engineers and a number of other professions. To improve the customer experience, robotic arms carrying out the (un)plugging of the cable, charging robots, portable or emergency solutions, and other innovative services will be introduced. Payments, billing and charging optimisation require software, IT and business development skills.

In many cases, the charging infrastructure is connected to **battery storage, photovoltaics**, and other systems as a part of the modern industry, energetics and smart homes, reducing the load on the grid and enabling new business concepts. Energy management, software development and IT are among the skills and qualifications required in this regard.

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Charging infrastructure is also growing rapidly inside **buildings**, ranging from big public garages for hundreds of vehicles to small private garages. Some of the garages are located underground. The growth is driven by customer demand, as in-house charging is often the most convenient solution for the customer, but also by the needs of future grid operation concepts. Vehicles connected to AC charging in buildings can reduce the need for public charging outside, where there are often space and other constraints. Moreover, using the **bi-directional** flow of energy that some EV models are capable of can help balance the grid.

However, since lithium-ion batteries (particularly NMC) are difficult to **extinguish,** new regulations, norms and guidelines are being introduced at the EU, national, regional and municipal levels to ensure fire brigades can respond quickly and effectively.

Fire brigades and other first responders, building designers, or safety engineers need to be trained on safety topics related to EVs and aspects of their charging. Electrical Engineers, Electrical Technicians, Safety Managers and other professionals are needed to roll out the charging infrastructure in sufficient numbers and timeframe. **Detection, extinguishing** and **ventilation systems** need to be designed, manufactured, installed and serviced across the EU in large numbers, involving, in some cases, retrofitting already existing mass parking garages.

Micromobility devices such as e-bikes, scooters or one-wheelers have been electrified without a regulatory push, mainly driven by customer demand, the increased availability and performance of lithium-ion batteries, and the deterioration of the traffic situation in city centres. Digitalisation made shared services in cities with positive business cases possible.

Aeroplanes seem to be, for the moment, far from mass electrification, mainly due to challenges related to the mass and weight of the battery complicating the aeroplane take-off. However, there are some first pilot projects in the segment of small planes, and some planes already received the relevant certification needed.

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Battery electric **trains** are also being piloted in Europe. The technology is competing with other alternative fuels, such as hydrogen.

Electrification of **vessels** brings a reduction of emissions and noise. Norway is among the leaders in vessel electrification. **Passenger/car ferries** operating between islands, in fjords or in maritime coastal areas are prone to electrification. Electric **fishing vessels** have the advantage of low noise. Commercial and leisure vessels on inland waterways also have a great potential to go electric. However, the charging infrastructure, relevant funding schemes, and EU or international charging standards are often missing.

At the end of vehicle life, a disassembly of the vehicle and its battery pack will be needed, followed by battery diagnostics and separating good cells and modules for a **second life** and cells in a worse shape for **recycling**, requiring a skilled workforce having electrical, mechanical and chemical expertise, among others.

In several instances, industry representatives highlighted that throughout the battery value chain, people with **deep expertise** in a particular battery topic and, on the other hand, people with very **wide knowledge** would be required because a "widely" educated person can more easily cooperate with teams from other sectors.

Relevant job roles, skills, qualifications for the means of transport mentioned above, and their charging are described in detail in this and the other ALBATTS project reports, which are available for free on the project website.[1] The streams, presentations and other details concerning the **webinars and interviews** mentioned further in this report are also available on the ALBATTS project website.[2]

It is worth mentioning that there is unlikely to be a **"one-size fits all"** educational and training solution for all the EU member states. They differ with regard to what battery-relevant

[1] Project ALBATTS. (2023). https://www.project-albatts.eu/en/results
[2] *Project ALBATTS*. 2023). https://www.project-albatts.eu/en/listnewsevents?slug=aboutus

industry is present there. There are countries and regions where **gigafactories** are built or planned. Others have solid **automotive industry** (but in some cases, no gigafactories in sight), some have deposits of the **raw materials** and can specialise in their mining and processing, and some tend to focus on supplying specific **components** such as anode or cathode materials production or explore opportunities in the area of **recycling**.

There is a tough **fight for talent** in battery-relevant topics among the sectors. In some countries and regions, the emerging European battery industry is being supplied by partly or fully qualified personnel from the **automotive industry** with experience with highly automated precise mass production or from **chemical** and **pharmaceutical** industries with experience with extra clean production environments, also needed for batteries.

2 Introduction and Methodology

This report was produced by the *Work Package 5 – Intelligence in Mobile Battery Applications* of the **ALBATTS** (Alliance for Batteries Technology, Training and Skills) project. It summarises the **main findings** of the recent Work Package 5 reports and other activities related to battery-relevant trends, drivers of change, state-of-the-art technologies, as well as job roles and qualifications needed by the emerging EU battery sector, particularly in the area of **mobile applications** of batteries.

The report focuses on key findings, skills agenda, and recommendations concerning training, re-/up-skilling, and specific skills needs within the analysed domains.

The following information is summarised in this report:

1) The main findings of the ALBATTS WP5 D5.10 desktop research report *Charging Batteries of Electric Vehicles and Other Electric Means of Transport & Job Roles and Skills* focused on state-of-the-art **charging technologies** researched during 2. Q and 3. Q 2023 relevant to charging of electric:

    1) Passenger cars
    2) Heavy-duty vehicles – trucks, buses
    3) Motorbikes, mopeds
    4) Micromobility
    5) Aeroplanes
    7) Trains
    8) Inland waterway vessels.

It includes job profiles desired by the industry in publicly available **job advertisements,** together with relevant findings from various sources analysed within the desktop research.

2) Information on current and future industry needs and other relevant data gathered via the **interviews and webinars** organised by the ALBATTS WP5 members with the support of the other project members between October 2022 and January 2023 report, namely:

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1) "Future Battery Technologies" – Interview with Doc. Tomáš Kazda
2) "Future Battery Technologies" – Interview with Prof. Dr. Noshin Omar
3) "Electrification of the Aviation Sector" - Webinar
4) "Electrification of Heavy-duty Vehicles" – Webinar
5) "Electrification of Inland Waterways" – Webinar
6) "Safe Recycling & Second Use of EV Batteries "- Webinar.

The report's findings have also been **enriched** by knowledge gained by the authors of the report in the time that has passed since the reports mentioned above were published. The report findings are **further elaborated** within the final WP3 – Sectoral Intelligence report, where the data are merged with the main findings of a parallel report prepared by ALBATTS project "sister" *Work Package WP4 - Intelligence in Stationary and Industrial Battery Applications.*

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3 Charging of Electric Vehicles

This chapter summarises key findings of the ALBATTS delivery D5.10 ***Desk Research Report IV.: Charging Batteries of Electric Vehicles and Other Electric Means of Transport & Job Roles and Skills***.[3]

The report analyses drivers of change, technologies, stakeholders, job roles, skills and qualifications relevant to the charging of batteries in electric passenger cars, trucks and buses, motorbikes, mopeds, micromobility devices, aeroplanes, trains and vessels.

[3] Charging Batteries of Electric Vehicles and Other Electric Means of Transport & Job Roles and Skills. (2023). In *Albatts*. https://www.project-albatts.eu/Media/Publications/91/Publications_91_20231010_74042.pdf

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3.1 BATTERY CHARGING PRINCIPLES

The first chapter describes the basic principles and ways of charging. It also provides insights into the recommendation of some OEMs (and a relatively common practice of many EV drivers) to charge the battery not entirely but to around **80%** only. It examines the problem of **degradation** of batteries due to fast charging. Among possible solutions to mitigate the degradation are technological enhancements in battery chemistry, design and battery management system (BMS).

Skills Agenda and Recommendations

The EU educational system shall adjust to provide the job market with researchers and developers highly qualified in the areas of **material optimisation**, **electrode engineering**, and **electrolyte enhancements**, where the most significant challenges are foreseen.

While the EU lags behind China and other Asian competitors in lithium-ion technology, it might catch up in the advanced lithium-ion battery technologies or new battery technologies approaching market readiness as **sodium-ion**. Some European companies already have advanced know-how and experience with **BMS,** and this is another area with high potential.

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3.2 CHARGING OF PASSENGER CARS

Background

The electrification of **passenger cars** has been driven, among other drivers, by advancements in lithium-ion battery technology, national and local regulations incentivising electric passenger cars, and, most of all, **EU legislation.**

The most significant legislation on the EU level includes the CO_2 emission performance standards for new passenger cars and new light commercial vehicles (EU regulation 2019/631). It introduces fleet **CO_2 emission reduction** targets, pushing car manufacturers to increase the number of electric vehicles on the market gradually. Approved within the "Fit for 55" package, the EU regulation 2023/851 tightens, even more, the existing emission reduction targets and, further to that, allows, starting from 2035, only zero-emission vehicles to be put on the market, except for ICE vehicles fueled solely by zero-emission synthetic fuels.

Among other drivers of electrification on the EU level is the revised Clean Vehicles Directive (2019/1161), which introduces compulsory zero-emission vehicle **quotas** for public tenders of passenger cars, but also trucks and busses for each EU member state. According to the directive, Germany, for example, must purchase 38.5% of zero-emission vehicles for public fleets by 2030.

Energy Performance of Buildings Directive (EPBD) 2010/31/EU introduces compulsory targets for charging infrastructure and **pre-cabling in buildings;** the revision is, as of the end of 2023, in the final stage of the EU legislative process, expected to bring even more ambitious targets.

The new AFIR, based on Commission proposal COM(2021)0559, sets binding **public charging infrastructure** targets for each member state. For example, the AFIR requests there are charging points for passenger cars on the highways on the TEN-T core network (the most significant interstate highways) with at least 400 kW output in the distance not exceeding **60 km** from each other by 2025 and with at least 600 kW by 2030.

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Types of Charging and Eelated Innovative Concepts and Services

Electric cars are charged mainly **by cable** at home, work, or public charging stations at shopping centres, highway stops, and similar places. Particularly in the case of home charging, the combination of a charging wallbox with photovoltaics and battery storage is often used. Advanced movable energy storages can be used in garages to ensure automatic recharging or robotic arms can plug/unplug the cable and thus increase customer comfort.

Static wireless charging options are being explored to avoid the need to handle the cables and to increase customer comfort. The possibility of **dynamic wireless charging**, using the coils placed underneath the road surface, is being tested. The Chinese company Nio has introduced **battery-swapping** stations to several Western and Northern EU countries.

Innovative concepts and services are being explored concerning **V2X** (Vehicle-to-everything), where the electric vehicle supplies the energy to the grid (helping balance it), another vehicle, a household (in case of a blackout, for example) or various tools and gadgets. Other areas opening new business opportunities are, for example, solutions smoothening the **search** for (available) charging stations, ensuring **payments** and billing, managing large **company fleets** and their charging or **emergency and portable** charging solutions.

Examples of Job Roles, Skills and Qualifications

Examples of job roles, skills and qualifications sought by companies and research centres in job advertisements follow. Some of these examples are from the US, and they mainly concern R&D and charging infrastructure rollout:

High Power Vehicle Charging Infrastructure Postdoctoral Research Associate

- PhD in Electrical Engineering (mechanical, automotive engineering, or computer science)
- Knowledge of electric vehicle service equipment (EVSE) and EV technology, expertise in experimental design, data collection, programming, analysis, and testing.

Electric Vehicle Charging Hardware Systems Researcher

- Knowledge of electric vehicle technologies, such as high voltage batteries, inverters, and chargers; grid and electric vehicle supply equipment (GEVSE), communication networks for integrated EV-Grid operation
- Familiarity with low-voltage (<600 V) electrical infrastructure components, design, and protection practices
- Experience with digital real-time simulators, electrical system simulation programs
- Understanding of electric vehicle-related interface and communications standards
- Experience in projects using smart grid control interface systems
- Knowledge of utility-related standards
- Experience with hardware testing and/or prototype system development.

Senior Charging Infrastructure Engineer

- Bachelor or higher degree in Electrical Engineering
- Compliance, and classifications, design standards and guidelines.

Senior Reliability Engineer - High-Power EV Charging Hardware

- Relevant PhD or Master's degree and work experience
- Experience with design, manufacturing, and/or deployment of outdoor-rated electronics used in communications, control, and/or power conversion
- Familiarity with AC (<600 V) and/or DC (<1250 V) electrical infrastructure components, design, and protection practices.

Senior Hardware Engineer

- Bachelor's degree in Electrical Engineering or equivalent work experience
- Experience in developing hardware for production products
- Experience with test equipment, including oscilloscopes, and logic analysers
- Expertise in testing and troubleshooting electronic systems
- Experience with power electronics, and AC power systems.

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Electric Vehicle Charging Technician

- An electrician or electrical repair experience or electric vehicle charging repair experience
- Computer skills.

EV charging expert

- Bachelor's or master's degree plus product support or engineering experience
- Experience with and knowledge of working with utilities, solar installations, electrical contractors, getting permits, EV knowledge, working with interoperability between vehicle and charger
- Experience with site assessments to determine power requirements and evaluate charger locations, EV charger site design.

Skills Agenda and Recommendations

Numerous new jobs will be created to provide charging solutions for the growing fleet of electric vehicles and to fulfil the **AFIR, EPBD** and other EU regulatory targets concerning public charging infrastructure and charging infrastructure in buildings. **Planning, designing, installing, upgrading** and **maintaining** the existing and upcoming charging stations and their connection to the grid, photovoltaics, battery energy storage, and other systems will require much effort, investment and a qualified workforce.

In this regard, the EU shall ensure it provides the job market with sufficient numbers of **Electrical** and **Hardware Engineers**, **Charging network planners and Managers, Project and Energy managers, Sales and Customer care representatives**, and other professionals to **design and implement wired or wireless charging stations** and perhaps also, into some extent, **battery swapping stations.**

Skilled personnel will be needed to deal with their **connection to the grid, battery storage, photovoltaics system, smart charging** and **intelligent energy home systems**, and create and implement **innovative services and products** relevant to charging. The emerging innovative

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services and products relevant to charging may be related to **Vehicle-to-Vehicle Recharging (VVR), Vehicle-to-Everything**, **fleet charging management systems, payments, emergency** and **portable charging solutions** or **(automated) robotic charging systems.**

At the blue-collar level, technicians, particularly **electricians,** will be needed in large numbers **to install, maintain and upgrade** private and public charging stations; other personnel will be required to **develop and maintain software and payment systems**, deal with **troubleshooting** or **administrate** building and other **approvals** or facilitate the connection of the stations **to the grid**.

Installing charging stations (mostly slow/AC) in garages of various types of residential, administrative, commercial or public buildings, boosted by the EPBD requirements, will need **building designers** to implement effective charging solutions.

Since lithium-ion batteries (particularly NMC) are **difficult to extinguish**, particularly in enclosed (underground) areas, ensuring the safety of EVs in buildings, mainly when these are being charged, will be an enormous task for the member states. **Prevention** of an incident is the most important - safe charging of more significant numbers of EVs in buildings will require **certified electricians** to install the stations and periodically revise them. The periodicity of the checks depends on regulations in place in the individual member states.

The **designing and installation** of **fire detection, extinguishing systems, smoke and heat removal equipment** in new buildings, as well as **retrofitting** some of these safety systems in the existing garages to ensure safe EV charging, will require qualified professionals in the area of **fire prevention and extinguishing** and **real estate safety design.**

At least basic instructions concerning EV charging and EV batteries shall be provided to **all EV users** (typically at the vehicle sales point), and more advanced training for **professional drivers** and **driving school instructors.** Specifics of EVs and their charging shall become part of the **driving school curricula.**

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Emergency first responders must be trained to understand how to disconnect the high-voltage traction battery in case of an incident, for example. They need to be able to quickly find specifics of the vehicle in their systems – how the battery pack is stored in the vehicle, what the battery chemistry is, and so on. **Fire brigades** need to be trained to extinguish BEV fires and deal with the extinguished vehicle.

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3.3 CHARGING OF TRUCKS AND BUSES

Background

The EU introduced emission targets for HDV (heavy-duty vehicles) – heavy lorries and tractors - in 2019 (EU Regulation 2019/1242). Their CO_2 emissions should decrease **by 15% in 2025 and 30% by 2030**. In 2023, the EU Commission proposed a revision of the targets to enlarge the scope to include urban buses, coaches, trailers and other types of lorries and make the targets for most of the types of HDVs stricter: **by 45% in 2030**, 65% in 2035 and 90% in 2040. According to the proposal, all newly registered city buses shall be emission-free (meaning battery electric or fuel cell) from 2030.

To achieve the zero emissions goal set in the Fit for 55 package and help enable the expansion of e-mobility, the EU has approved **the AFIR,** which introduces, among others, compulsory density and output of public chargers (and hydrogen refuelling stations) for HDVs across Europe, leading to at least public 11,000 charging stations in 2030.[4]

- Core highways within TEN-T network: charging nod every 120 km or 15% coverage with a minimum of one charger with power 350 kW and a minimum of 1,400 kW per nod in 2025, charging nod every 120 km or 50% coverage with 2,800 kW per nod with minimum one 350 kW charger in 2027 and 3,600 kW nod every 60 km with minimum two 350 kW chargers in 2030
- Secondary highways within TEN-T network: charging nod every 120 km or 15% coverage with a minimum of one charger with power 350 kW and a minimum of 1,400 kW per nod in 2025, charging nod every 120 km or 50% coverage with 1,400 kW per nod with minimum one 350 kW charger in 2027 and 1,500 kW nod every 100 km with minimum one 350 kW chargers in 2030
- Urban charging nods: minimum charging power 150 kW per charger with a minimum of 900 kW; the minimum is 6x150 kW chargers per nod in 2025 and 1,800 kW, the minimum is 12x150 kW chargers in 2030

[4] European Union Alternative Fuel Infrastructure Regulation (AFIR). (2023, April). *The International Council on Clean Transportation*. https://theicct.org/publication/afir-eu-april2023/

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- Secured truck parking lots: at least two 100 kW chargers in 2025 and four 400 kW charges in 2030.

Electric trucks and buses operate on urban and sometimes regional routes and charge in **depots**. In the future, when public heavy-duty charging infrastructure is in place, and improvements in battery technology are made, **regional**, **national** and perhaps even **international** journeys shall be possible.

Lighter trucks (N1 and N2 categories) seem to be easier to electrify than **heavy trucks** (N3). The fastest uptake of electric trucks and buses can be expected in cities with low or zero-emission zones and countries where subsidies are in place, subsidising the higher purchase price and thus lowering the total costs of ownership (TCOs). For longer international journeys, **hydrogen** and **bio LNG** will also be among the main alternatives to diesel.

To achieve a positive business case with electric heavy-duty vehicles, **supporting schemes** must be introduced by the member states, such as cheap energy from photovoltaics in depots, **discounted or zero tolls**, purchase subsidies, and, of course, environmentally sensitive customers willing to pay extra money for a, for the moment, still slightly less reliable transport.

Types of Charging

Dynamic charging of trucks using coils placed underneath the road surface is being tested on certain road sections on the Swedish island of Gotland. However, for the moment, it is far from a more considerable uptake due to the limited efficiency of the energy transfer, particularly at higher speeds and the high costs and effort needed for the dynamic charging infrastructure rollout. **Battery swapping** is being tested with trucks in China, where an empty battery pack is exchanged for a full one at a relevantly equipped swapping station.

Nevertheless, as in the case of passenger cars, **wired charging** is the most common way of charging. The public charging infrastructure was almost non-existent in Europe at the time of writing this report, and the existing trucks and busses were dependent on **charging in depots,** which limits their operating range. Electric trucks can also be charged when uploading or unloading the cargo **at the customer's.**

Due to the AFIR, as mentioned above, **public charging infrastructure** for heavy-duty vehicles is expected to be rolled out across the EU member states, sometimes combined with solar parcs and battery storage systems helping the grid with the high power input needed in time of charging. To ensure the power supply to heavy-duty vehicles with a battery pack having a capacity of hundreds of kilowatt-hours, the **MegaWatt Charging System (MCS)** standard is being developed, which could provide a charging capacity of up to **3.75 MW.**

Charging hubs - large parking and charging parks are expected to be designed and built along highways where a combination of parking and charging areas for heavy-duty vehicles will be built, together with areas for filling hydrogen and bio LNG vehicles.

Similar to other commercial vehicles, trucks are expected to be **in use 24/7**, and there is not much room for lengthy charging, except for a limited number of breaks, such as **compulsory driver rests**, as required by the EU legislation.

Electric buses are, compared to trucks, not that uncharted territory. They have been present across Europe for years, mainly for **inner-city** journeys. Further to charging in depots, buses can **charge in stops** while passengers get in and out **wirelessly** or via various forms of **pantographs**. Similar to trucks, long international journeys by electric buses are among the most significant challenges ahead.

Examples of Job Roles, Skills and Qualification Needs

Charging Infrastructure Technician/Installer:

- Knowledge of electrical systems and components, ability to install and maintain charging infrastructure, understanding of safety protocols, troubleshooting skills, and familiarity with relevant codes and standards.

Charging Station Network Operator**:**

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- Management of charging station networks, monitoring and maintenance of charging infrastructure, software and technical skills for network operation and maintenance, customer support, data analysis and reporting.

Fleet Manager/Transportation Planner:

- Understanding of electric vehicle technology and charging infrastructure, knowledge of fleet management principles, ability to plan and optimise charging schedules and routes, data analysis for efficient fleet operations, and familiarity with energy management systems.

Electric Vehicle Technician/Mechanic:

- Knowledge of electric vehicle systems, including charging systems, batteries, and electric drivetrains, ability to diagnose and repair EV charging-related issues; understanding of safety protocols for high-voltage systems, proficiency in electrical troubleshooting.

Energy Management Specialist:

- Understanding of energy management principles, knowledge of charging infrastructure and its impact on grid integration and demand response, ability to analyse energy consumption patterns and optimise charging strategies, familiarity with smart charging technologies and energy storage systems.

Electrical Engineer:

- Design and engineering of charging infrastructure, proficiency in electrical system design and calculations, knowledge of power distribution, charging protocols, and electrical safety standards, and ability to develop and implement charging solutions for specific applications.

Customer Support and Service:

- Strong communication and interpersonal skills, ability to provide technical support and guidance to EV users and fleet operators, knowledge of charging processes and equipment operation, problem-solving abilities, ability to address customer inquiries and resolve issues.

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Skills Agenda and Recommendations

The demand for professionals with expertise in EV charging and related areas is expected to increase. **Continual learning**, staying updated on emerging technologies and industry standards, and adapting to evolving EV charging infrastructure are essential for professionals in these roles.

Job roles and qualifications relevant to **designing, rolling out, maintaining, and upgrading** the charging infrastructure for trucks and buses are somewhat **similar to the segment of passenger cars**, the main difference being that **much larger** battery packs and charging powers are needed.

Specific tasks concerning the rollout of charging infrastructure for heavy-duty vehicles include the **design and building** of charging hubs in **logistic centres** and **resting areas** along highways, with sufficient parking space, power installation and organisation of transport, which needs to be smooth.

Depot charging and charging opportunities when **up and unloading** the load at customers will need to be deployed for the trucks. Charging in depot installations will be necessary for buses, potentially combined with top-up charging opportunities **using pantographs,** for example, at **bus stops. Software solutions** ensuring smooth and effective **routes and charging planning** to avoid unnecessary queuing will be needed.

Advanced **BMSs** will need to be developed to prevent damage to the battery when it is charged with high power. Specific **hardware systems** such as high-power charging stations, trolleys, wireless solutions or specific (robotic) arms helping the driver to handle the thick, heavy charging cables will need to be **developed, manufactured and installed** at the depots, at the customers and public heavy-duty charging stations and hubs.

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3.4 CHARGING OF MOTORBIKES

Background

Unlike the segments of passenger cars and heavy-duty vehicles, motorbikes and mopeds are being electrified **without** a stronger EU regulatory push. Among the drivers behind the steep market increase of electric motorbikes are technological improvements in lithium-ion battery technology, its price decrease and the spread of shared motorbike services in some European cities.

In **China** and other Asian countries, electric motorbikes have been present in cities in large numbers for some time already. Worldwide, electric models have been introduced by **established** motorbike brands which also have ICE motorbikes in their portfolio, as well as **start-ups** focusing solely on electric motorbikes.

Types of Charging

Motorbikes and mopeds are mostly charged from a **regular 230 V socket** at home or in **charging depots** in shared motorbikes and mopeds in the case of shared city mobility services. They can be charged using **public AC** charging, and some motorbikes with a more significant battery capacity, designed for longer routes, also using **public DC** charging.

In China and other countries outside the EU, **battery-swapping** services are provided. In the case of passenger cars and trucks, the swapping is executed automatically by robotic systems without the interference of the driver. In the case of battery swapping for motorcycles and mopeds, the customer executes the swapping **himself/herself,** removing the empty battery, which is portable and not heavy, relatively easily from the device and replacing it with a full one taken from storage devices where the shared battery modules for motorbikes are stored and charged.

Examples of Job Roles, Skills and Qualification Needs

The activities performed with regard to motorbike and moped charging include:

- R&D – developing and designing batteries and other electric systems for e-motorbikes

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- Manufacturing – electric motor and battery pack assembly for e-motorbikes
- Servicing – maintenance of electric motorbikes (motor and batteries), malfunction diagnosis, servicing or replacement of malfunctioning or end-of-life battery packs and refurbishing of the battery packs
- Operation - assistance with charging
- Disassembly - end-of-life e-motorbikes and battery packs
- Thorough understanding of prototypes: hardware design, software development, EMC compliance, and functional testing
- Embedded product development: in-vehicle and outside-vehicle deployment of various data protocols
- Electrical power line installation and maintenance
- Equipment testing
- Technicians (switches, transmitters, and light fixtures).

The market is already scrambling for the workforce necessary to create, expand and maintain the infrastructure necessary to ensure the proper functionality of the electric vehicle fleet. For instance, the employers are offering on a single UK recruiting platform[5] over 350 jobs that are solely related to EV charging (which are also relevant for e-motorbikes), such as:

- Field Service Technician – EV Charging Units
- Senior Electrical Diagnostics Engineer – EV Charging (DC)
- Installation Project Engineer – EV Charging Installation
- Lead Control Systems Engineer – EV Charging
- Electrical Project and Standards Engineer – EV Charging Infrastructure.

<u>Skills Agenda and Recommendations:</u>

No specific recommendations - job roles, skills and qualifications relevant to the charging of electric motorbikes are largely similar to those mentioned in the passenger cars chapter.

[5] 343 EV Charging Jobs (NOW HIRING) | ZipRecruiter. (n.d.). *ZipRecruiter*. https://www.ziprecruiter.co.uk/Jobs/EV-Charging?utm_source=zr-go-redirect, 13.06.2023

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3.5 CHARGING OF MICROMOBILITY DEVICES

Background

Electric micromobility includes small and lightweight personal mobility devices such as **e-bicycles, e-scooters, e-skateboards, e-hoverboards** or other kinds of one or two-wheelers to be used by individuals to cover short distances within cities and city centres but also outside them.

Electrification of these mobility devices is also driven by the widespread availability and decreased price of lithium-ion batteries and by **customer demand**, not by EU regulation. The micromobility devices can be owned privately, for use by corporate customers or by companies providing mobility services, particularly in urban areas.

Types of Charging

Charging of micromobility devices mostly takes place **at home** or dedicated areas of **corporate premises**, primarily using a regular 230 V socket. Public charging might not be necessary to be installed since the devices are mainly able to cover the distance without charging on the way. For **e-bikes**, public charging infrastructure using multiple plug and socket types is being installed at some tourist destinations and hotels. Some shared mobility services use **charging racks**, where the bike is locked and charged.

Examples of Job Role, Skills and Qualification Needs

Some of the most essential job roles, skills and competencies identified within this sector:

- Systems Engineer for Battery Management Systems – one of the most desired job roles in the sector, requires studies in the field of electrical engineering and good knowledge of battery systems and lithium-ion cells, with strong programming skills
- Product Design Manager – another job very desired in the shared micromobility – with a focus on solid experience in building and shipping applications or software and different design tools Sketch, Flinto, InVision, and Framer
- Electrical Engineering Technicians with competencies in retrofitting, maintaining and repairing wireless charging units

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- Infrastructure development – with a focus on the development of proposals for new electric vehicle charging infrastructure, commercial activities related to the deployment of new charging infrastructure, identifying wider opportunities to unlock funding for new charging infrastructure, oversight of the delivery of publicly-funded charging infrastructure, provide effective and efficient project management of EV-related projects, including the management of internal colleagues, contractors and budgets, provide technical advice on EV charging matters and support for the deployment of the EV charging network
- Infrastructure operation and maintenance – with a focus on activities specific to battery swapping stations: maintain charging units safety and functionality, defective battery replacement and shipping, provide assistance to end users to replace batteries, unlock charged batteries, pay for the service, etc.
- App Developer
- Data Analyst.

In general, many job roles rely on solid **IT skills** and **electronics/electrical engineering** and experience in software engineering. Additional competencies include strong communication skills, business intelligence, measurement and test technology handling.

Skills Agenda and Recommendations:

For the micromobility segment, the EU educational and training system shall provide sufficient numbers of **Electrical engineers** and **Technicians with Software/app developing skills** and **Data analysts**. Designing and planning the public charging infrastructure requires **Electrician engineering** and technician professions with similar qualifications as needed for passenger car charging stations; only the capacity of the batteries and the power to charge them is substantially lower.

Software skills (App developers) and **Data analysts** are needed to monitor and plan the charging or battery swapping of the shared micromobility devices. Replacing the batteries in the shared micromobility devices might be executed with **personnel with basic training.**

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3.6 CHARGING OF AEROPLANES

Background

The electrification of the propulsion of aeroplanes is in a very **early stage** compared to other mobile applications. The **weight** of the batteries is among the most significant challenges, limiting take-off range possibilities and thus also limiting more considerable market uptake.

Nevertheless, there have been some exciting pilot projects and first attempts at commercial use, such as the fully electric single-engine two-seater **Pipistrel Velis Electro** or the 7-seater **Lilium Jet e-vtol**.

Types of Charging

Similar to other electric battery transport devices, a combination of **AC** (1 and 3-phase) and **DC** charging are used for the pilot aeroplane projects. The upcoming **MCS** is also being considered.

Skills agenda and recommendations

Since the electrification of propulsion of aeroplanes is in an **early stage,** relevant job roles, skills and qualifications have not been identified.

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3.7 CHARGING OF TRAINS

Background

Large parts of EU train lines have already been electrified, with trains using trolleys to get the energy from lines installed above the trains. However, many routes are not electrified yet, and this is where trains with diesel engines dominate, sometimes using hybrid propulsions where batteries and electric motors provide an extra boost of energy during the start.

Among the challenges are the **weight and price** of the batteries, the energy required to **set** a heavy train with cargo in motion, and the lack of **charging infrastructure** able to provide sufficient power. **Recuperation** of the energy during braking is among the main advantages.

First trains running fully on electricity from batteries, instead of being powered by diesel engines, have been piloted in Germany since May 2023. Some tenders for battery trains are considered in other EU countries, such as the Czech Republic, for example.

Types of Charging

Battery trains can be charged in the **depots** using DC charging or can top-up the energy at stops when the passengers get on and off, using **overhead DC trolleys**, for example.

Skills Agenda and Recommendations

Since the segment of battery electric trains is relatively immature**,** relevant job roles, skills and qualifications have not been identified.

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3.8 CHARGING OF VESSELS

Electricity will have significant cost benefits in a few years compared to diesel and other fuels, primarily driven by regulation and taxation (the inclusion of transport in the ETS, national taxation). Electricity is, in many cases, **already available** in the port areas without the need for costly infrastructure upgrades. **On-shore charging** is a low-hanging fruit in the journey towards a low-carbon Europe.

Ensuring **charging infrastructure** in the maritime and inland waterway ports is necessary to enable the electrification of vessels. Moreover, vessels connected to shore power in port can turn off generators for needed energy onboard. The effect is cleaner air, reduced noise, and reduced emissions in the port area. Shore charging will reduce CO_2, NO_x, and SO_x emissions.

There is **no international standard** for maritime shore-side charging other than safety standards. More standardisations will empower flexibility and enable vessels to share the same port charging capacity. Standardisation is an enabler for less cost and more environmental benefits.

More than **1,000 vessels** worldwide will soon be hybrid or fully electric. 63% are registered in Europe, setting our region in the lead position. The **ferries** for passengers and their cars have been taking the lead in electrification. These are often used for short distances in bays, between islands and the mainland or in fjords. **The leisure boat** segment is also expected to go electric to some extent.

Types of Charging

Charging solutions come in different designs for different use cases: typical compact, telescopic, and classic designs. **Charging towers** and **power swap** solutions are also available.

From a power system view, solutions for **power supply from shore** consist of an interface to the main grid by a step-down transformer, possibly an energy storage system typically based on Li-ion batteries, power electronics converters responsible for AC/DC and DC/DC

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conversion, transformers for maintaining the galvanic isolation as well as voltage level adjustment, circuit breakers and cable management systems.

The shore-to-ship interface consists of plugs and receptacles, cable management systems, mechanical structures, and monitoring systems.

Examples of Job Roles, Skills and Qualification Needs

Many new job roles and skills are foreseen to be required to enable a broad and efficient shore charging network for maritime usage across Europe in four key areas:

1. R&D
2. Manufacturing
3. Servicing
4. Operation.

Open positions, job roles and skills for selected key companies:

1. Stemmann (Germany) career pages had the following open positions (June 2023):
    - Industrialisation Engineer
    - Junior project manager
    - System engineer
    - Senior project manager
    - Regional sales manager
    - Tender manager
    - Field service technician
    - Sales Support.

2. Cavotec (Switzerland) career pages had the following open positions (June 2023):
    - Business Controller
    - Mechanical Engineer - Charging Solution
    - Electrical Engineer - Charging Solution

- Software and Controls Engineer - Charging Solution
- Quality Assurance Engineer
- Field Service Technician
- Mechanical Engineer (Moormaster) - Ports and Maritime
- Controls & Automation Engineer.

Skills Agenda and Recommendations

For the purposes of vessel charging, the EU educational and training system shall provide the job market with **Mechanical, Electrical, Software, Controls and Automation Engineers,** which are among the most desired professional backgrounds within the segment.

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4 Webinars and Interviews

The following chapter summarises the **report *ALBATTS Workshops: Battery Relevant Job Roles & Skills: Impact of Technological and Legislative Trends***,[6] highlighting key findings, skills agenda and recommendations.

[6] *ALBATTS Workshops: Battery Relevant Job Roles & Skills - Impact of Technological and Legislative Trends.* (2022, February). Albatts. https://www.project-albatts.eu/Media/Publications/62/Publications_62_20220228_15859.pdf (last acessed on 27. 9. 2022)

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4.1 FUTURE BATTERY TECHNOLOGIES – INTERVIEW WITH DOC. TOMÁŠ KAZDA

The online interview "Future battery technologies: Job roles, skills and knowledge" with doc. Tomáš Kazda, the associate professor at the Department of Electrical and Electronic Technology, Brno University of Technology, was held on October 26, 2022. The interview was conducted by Prof. Helena Braga from the Engineering Faculty of Porto University, an ALBATTS project member.

Key Findings

- Future battery technologies currently being researched include advanced lithium-ion, sodium-ion, lithium-sulphur, lithium-metal, solid-state state, and **structural batteries**
- The Czech Republic (as well as Poland and other countries) has a history of coal mining and relevant education and training available. As coal mining is being phased out, these courses can be switched, and the workers can be re/up-skilled to mining and processing raw materials for batteries since there are deposits of lithium, manganese, graphite, and cobalt.

Skills Agenda and Recommendations

- EU educational and training system shall focus on **researchers and developers** in the areas of advanced lithium-ion and new battery technologies, as well as **Electrical engineers and Mechanical engineers**
- Re/up-skilling of the personnel from the diminishing coal mining industry for the extraction of battery-relevant **raw materials** such as lithium, manganese, graphite and cobalt shall be considered
- Unlike Asia and the countries outside the EU, some EU students find the technical and particularly battery-relevant fields of education unattractive. **The attractivity** of these fields shall be actively supported by the EU and the member states
- The EU educational system shall provide the workforce with both **deep knowledge** in specific areas, as well as a **very wide knowledge** to communicate with different sectors and connect them together

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- **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, and how to handle the battery.

4.2 FUTURE BATTERY TECHNOLOGIES – INTERVIEW WITH PROF. DR NOSHIN OMAR

The online interview "Future battery technologies: Job roles, skills and knowledge" with Prof. Dr. Noshin Omar, an associate professor at Mondragon University and the founder and CEO of Avesta Battery & Energy Engineering (ABEE) organised by the ALBATTS project partners, took place on November 14, 2022. The interviewer was Prof. Helena Braga from the Engineering Faculty of Porto University, an ALBATTS project member.

Key Findings

- **Lithium-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** will not be easy – different technology, different supplies… many needs in skills
- The biggest challenge when building a gigafactory is to ensure a **stable supply chain**
- **Sodium** technology to be used for stationary applications and low-performance mobility
- **Mass production** of batteries needed to lower their costs
- Ranges up to **200 – 300 km** are suitable for electric trucks; for longer ranges, hydrogen might be more suitable, similar to maritime vessels.

Skills Agenda and Recommendations

- The following job roles, skills and qualifications shall be prioritised: **Chemical engineers, Purchasing managers, Electrochemical engineers, Cell designers, Electrical engineers, Process engineers, Modelling, Thermo-management**
- Overall, the big gap in programmes in **education levels 5 to 7-8** needs to be addressed as a priority
- A recycling hub needs to be in every region or country to lower the footprint from the transport of waste, requiring **Recycling managers** and **Recycling technicians**
- Various target groups, including decision/policymakers such as the EU Commission personnel, shall be educated continually on **new battery topics** - the industry is changing very fast, and regulations lag behind.

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4.3 ELECTRIFICATION OF THE AVIATION SECTOR - WEBINAR

The webinar "Electrification of the aviation sector & Job roles and skills needed "organised by the ALBATTS project partners was held on January 17, 2023.

Key Findings

- Electrification or hybridisation of aircraft allows for new aeroplane concepts, such as **vertical take-off and landing**
- **Air taxis** for passengers or cargo for a very short distance (up to 20 km) are not economically viable
- Small passenger/cargo aeroplanes can contain a battery capacity of around **80 kWh or less** - smaller than in many EVs
- For hybrid aircraft, a distance of **700 km** and more shall be possible
- 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
- The weight of **tanks for hydrogen** complicates a broader use of hydrogen in aircraft.

Skills Agenda and Recommendations

- To enable progress in the field of electrification of aircraft, the EU shall prioritise education and training in the areas of **Power-train architecture, Battery design and Controller development**
- No special training for the **pilot** is needed. However, the **ground crew** must know the basics, such as to avoid touching the high-voltage systems.

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4.4 ELECTRIFICATION OF HEAVY-DUTY VEHICLES - WEBINAR

The webinar "Electrification of the heavy-duty vehicles: What skills and competencies will be needed?" organised by the ALBATTS project partners took place on November 29, 2022.

Key Findings

- Many truck manufacturers are dedicated to step-by-step decarbonisation of their fleets using **electric** trucks, but also **hydrogen** and other alternatives such as **bio LNG**
- Some truck manufacturers have set their own **internal decarbonisation targets**, such as 2030 – 60% of vehicles zero-emission vehicles, 2039 - 100%
- Heavy duty vehicles = daily or even **24/7 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; 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 - **MCS** – charge up to 80% in less than an hour
- Charging infrastructure in **the depots** needs to be rolled out
- The **mass, safety and degradation of the batteries** are among the main challenges.

Skills Agenda and Recommendations

- The essential skills for electrification of heavy-duty vehicles = **business** and **technical** – such as **safety with electrification, battery knowledge, and manipulations with the batteries** shall be supported and **Electro-mechanical engineering** and **Project leader, Energy management** positions prioritised
- People dealing with electric heavy-duty vehicles need to obtain at least **basic training** in the area of safety, batteries and manipulation and understand safety features in trucks: **monitoring, safety shutdown, electric protections**
- Electric truck drivers shall receive basic training on **driving behaviour, route planning and charging, and vehicle components**. Nevertheless, driving an electric truck is considered easier than driving a diesel truck

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- Different kinds of **competence levels** shall be supported **- experts/specialists** in specific areas – but also many with **general knowledge**
- Personnel in the area of **predictive maintenance** (**digital twin**) needs to be available to avoid vehicle defects and hefty penalties for not delivering the cargo on time
- Driving a small 4.25 t eVan with a driving licence for a 3.5 t vehicle - some EU member states such as Germany have introduced **mandatory training for electric van drivers**, which are heavier than ICE vans
- For repair shops and similar areas, a **certification** to use and also to move in an environment where **high-voltage devices** are present might be required
- Skilled personnel will be needed to develop and implement **wireless charging solutions** on the side of a vehicle and the infrastructure. One of the critical challenges for trucks is achieving a very **exact positioning** of the vehicle. In wireless charging, there is more considerable potential for buses that go the same way and have the same stops every day.

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4.5 ELECTRIFICATION OF INLAND WATERWAYS - WEBINAR

The webinar "Electrification of inland waterways & Future qualifications needed" organised by the ALBATTS project partners was held on January 26, 2023.

Key Findings

- The advantages of electrified inland waterway vessels include a **reduction in CO_2 and NOx emissions** and other pollutants, as well as **noise reduction**
- Hybrid-electrical **fishing vessels** allow for fishing without noise
- **Passenger/car ferries** are especially suitable for electrification. Tens of electrified ferries have already been in operation in Norway
- Land infrastructure requires **grid upgrade, photovoltaics, battery storage, charging tower** - transmission (22 kV, 400 V, 590 V, 690 V), **charging power (1,750 kW)**
- A fully electrified **container ship** can have a battery pack with a capacity of **6.7 MWh**
- To be economically 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

Skills Agenda and Recommendations

- For the electrification of inland waterway vessels, the EU educational system and re/upskilling activities shall provide the following job roles, skills and qualifications: **IT, cyber-security, programming skills, hands-on engineering and servicing skills, impact/lifecycles/circularity assessments, fire protection and safety**, **temperature monitoring and thermal runaway protection**
- Education for students shall include **a combination** of different types of fuel power (**batteries, H_2, LNG, diesel, solar panels**…)
- Specific training and assistance are often provided to the engineers on board from the **suppliers of the equipment** (batteries and relevant systems) from the suppliers so that they can act in case of errors.

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4.6 SAFE RECYCLING & SECOND USE OF EV BATTERIES - WEBINAR

The webinar "Safe recycling & Second use of batteries: Skills and competencies needed" organised by the ALBATTS project partners was held on January 27, 2023.

Key Findings

- The **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
- 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
- **Standardisation** bridges 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
- As of January 27, 2023, there was **no particular standard** concerning the recycling of EV batteries, only a draft
- 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 t** of hazardous materials and the extraction of **555 kg** of cobalt
- 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 the **second life/use**

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- 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
- The old/spent batteries are **volatile** 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.

Skills Agenda and Recommendations

- 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, including training on norms and standards
- In the segment of recycling and second use of batteries, the EU educational system and re/up-skilling initiatives shall prioritise the following job roles, skills and qualifications: **Automated dismantling, SoH estimation methods, Design for recycling & reuse, 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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