albatts

Alliance for Batteries Technology, Training and Skills

2019-2023

Sectoral Intelligence:

Mobile Battery Applications

Job roles and skills relevant to operation, repair, and maintenance of electric passenger cars and vessels

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List of Abbreviations

AC	Alternating current
AI	Artificial intelligence
BEV	Battery electric vehicle
BMS	Battery management system
CO_2	Carbon dioxide
DC	Direct current
EV	Electric vehicle
GPS	Global positioning system
HV	High voltage
ICE	Internal combustion engine
IIoT	Industrial internet of things
LIB	Lithium-ion battery
OEM	Original equipment manufacturer
PHEV	Plug-in hybrid electric vehicle
SoC	State of charge
SoH	State of health

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Executive Summary

The demand for Lithium-ion batteries has witnessed a sharp increase and mobile applications, especially **electric passenger cars**, represent a significant part of it. In the first quarter of 2021, 16 cars out of 100 registered in the EU were electrically chargeable (battery electric vehicles or plug-in hybrids). Gradually, demand for competencies and skills, even specific job roles related to battery mobile applications, has emerged and will rise. In the automotive industry (including repair and maintenance of vehicles), with a large workforce already working in the field, it is challenging to reskill employees with a mechanical background to electrical applications or to find sufficient personnel, e.g., with professional education in the field. As for **electric vessels**, Europe is the global leader. Currently, direct electrification is more likely to be viable in the shortsea segment. Large batteries are used primarily in car and passenger ferries, but the breadth of market segments is continuously increasing (e.g., coastal service oil carrier).

Based on the previous ALBATTS findings, a list of **trends and sub-trends** relevant to electric passenger cars and vessels' operation, repair, and maintenance was identified. The report then describes competencies and job roles needed in these segments and outlines recommendations for the current state-of-the-art of the sector and its future development. It also identifies the primary target groups/stakeholders.

Chapter 1 covers activities and trends related to **servicing, maintenance, repair,** and **dismantling** of batteries installed in electric passenger vehicles. Skills and competence for EV batteries maintenance and repair that need to be strengthened include especially these areas: EV and battery diagnostics and repair in general; high voltage competence and qualification; battery charge and discharge; battery management systems; safety; relevant standards and regulations knowledge. The lack of workers with high voltage qualifications seems to be rather urgent. When dismantling the EV battery, knowledge and skills in second life, refurbishment and recycling of batteries, digitalisation, and traceability of battery lifecycle are also needed. Dealerships and vehicle repair shops need to be adjusted, especially in terms of safety. They often also need to build and operate charging stations at their premises, sometimes complemented by storage systems and solar panels.

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Chapter 2 contains a selection of **customer services** related to the operation of EVs and their batteries. The range and volume of information provided in dealerships can vary across the regions. Methodological guidance, such as different manuals and training to the employees in dealerships, car rental, or shared mobility companies, could help in this regard. When it comes to smart charging and fleet management business, competencies in many areas need to be combined - battery and charging systems, business and software development, telematics, and grid functions. Companies dealing with charging infrastructure design, installation, and maintenance also need various competencies – including engineering, mastering building permit processes, battery-relevant safety, or IT and payment solutions. First-responders, fire, and rescue services need new methods, tactics, and specific training to deal with emergencies related to EV batteries. Research and development of new extinguishers or procedures will need to react to current and future battery technologies. We can also expect higher demand for towing and mobile charging services in the future. Competence within the driving schools should be updated, together with teaching materials, and strengthened to facilitate the electrification of road transport and structural changes in the automotive sector.

Chapter 3 relates to technical areas of **autonomous driving** and vehicle to grid (**V2G**) concepts and services. As EVs seem to be easier driven by autonomous systems than ICE vehicles, they are an essential driver of autonomous mobility. Cybersecurity skills/competence and knowledge related to the mobile applications of batteries in electric vehicles need to be prioritised when applying concepts of autonomous vehicles to ensure customer safety and privacy. When it comes to the Vehicle to Grid concept, it can bring crucial opportunities not only for improving renewable energy sources integration into the energy grid. Battery and grid-relevant knowledge, together with IT skills, will be needed to be strengthened.

Chapter 4 focuses on activities and trends related to technical aspects of electric vehicles and charging infrastructure **before** they can be placed on the market and put into operation and periodic **roadworthiness tests** of electric vehicles. Relevant technical expertise is closely linked to legislation and standards knowledge. Given the systemic shift and increasing

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complexity of the process of testing and homologation brought by EVs, massive investments in new technologies and systems for testing and certification companies and technical services need to be made. At the same time, employees of these companies will need to expand and improve their knowledge and skills, especially in electrical and high voltage fields and interoperability. In addition, these companies usually cover testing of charging infrastructure as well. Among others, digital communication, grid connection guidelines, and different safety standards must be followed. So far, specific processes for EVs during periodic roadworthiness tests do not exist. However, with the increased number of EVs in operation and development of the used cars market, attention to this area could be expected, as well as a need for upskilling existing employees or hiring new ones.

Chapter 5 deals with the **electrification of vessels**. Vessels travel across the oceans and can be more challenging to reach for service personnel than an electric road vehicle. For this reason, remote diagnostics and over-the-air updates are necessary. Apart from battery-related expertise (such as electrochemistry, high voltage qualification, or mechanical engineering), digital technology competence (remote diagnostics & fault finding, cybersecurity, data transfer, communication protocols, etc.) is crucial. Similar to electric vehicles, electrified vessels are better suited for autonomous sailing. Strengthening the skills and training people in digital technology for autonomous systems - data scientists, test engineers, software developers, cloud solutions experts, and cybersecurity experts and engineers, is necessary. For product design and consulting, combining skills of internal combustion engines, batteries and programming is crucial. In addition, knowledge of safety requirements for maritime should be strengthened (e.g., thermal management, off-gas handling, system-level safety, or risk evaluation).

The primary sources of information used for this report, apart from specific knowledge of ALBATTS project partners involved, are listed at the end of the document.

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Introduction

Electrification of passenger vehicles

Global demand for Lithium-ion battery (LIB) cells was around 200 GWh in 2019. About **126 GWh**, the central part, of this was attributable to the electric mobility sector. Thus, in 2020, due to increasing sales of electric vehicles, the demand for LIB cells increased, based on estimates, to **over 150 GWh** (and over 250 GWh total global LIB demand). In 2025, motive applications could constitute more than **75%** of the market demand[1] (see **Figure 1**).

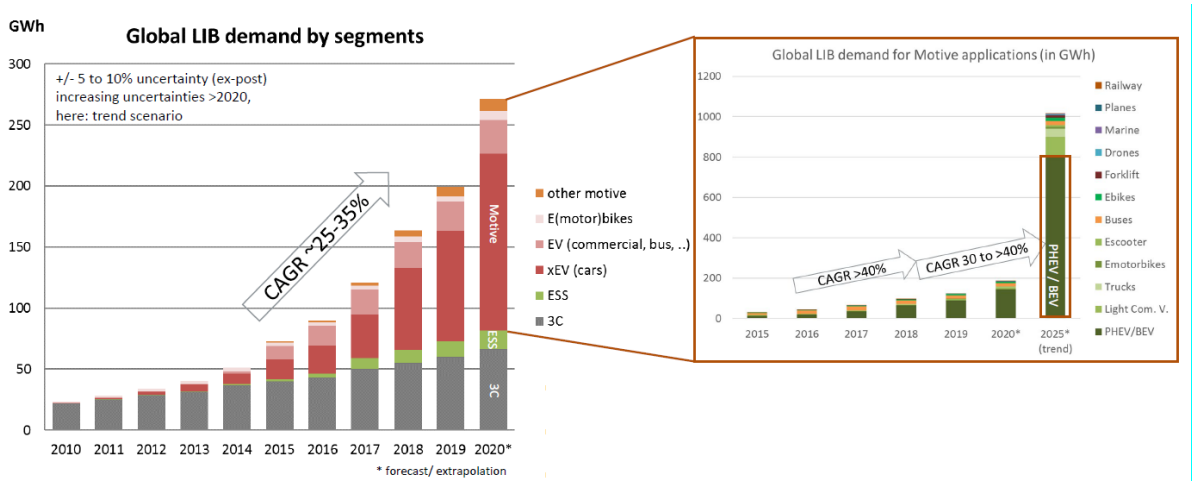

Figure 1: Global Lithium-Ion battery demand by segments[2,3]

Electric vehicles (EVs) sales have been growing at a fast speed in the last years due to a combination of policy support, more charging infrastructure being built, improvements in battery technology (average battery energy density is rising at **7%** per year, new chemistries coming to the market, etc.), cost (Lithium-ion battery pack prices fell **89%** from 2010 to 2020, with the volume-weighted average hitting $137/kWh) and new compelling models from OEMs.[4]

[1] *VDMA, in cooperation with Fraunhofer ISI, RWTH Aachen University and Battery LabFactory Braunschweig and TU Braunschweig. Roadmap Battery Production Equipment 2030.* Update 2020; A. Thielmann, Ch. Neef, Fraunhofer ISI. Towards a European battery economy 2030+, Battery Market – supply and demand worldwide and in Europe. Virtual Battery Exhibition 2021, presentation held on 29/04/2021

[2] Thielmann et al. 2018. Fraunhofer ISI. (December 2018). *Energiespeicher-Monitoring 2018 (Leitmarkt und Leitanbieterstudie: Lithium-Ionen-Batterien für die Elektromobilität.* https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cct/lib/Energiespeicher-Monitoring_2018.pdf (accessed on 25/08/2021)

[3] A. Thielmann, Ch. Neef, Fraunhofer ISI. *Towards a European battery economy 2030+, Battery Market – supply and demand worldwide and in Europe.* Virtual Battery Exhibition 2021, presentation held on 29/04/2021

[4] *BloombergNEF. Electric Vehicle Outlook 2021.* (2021). BloombergNEF. https://about.bnef.com/electric-vehicle-outlook/ (accessed on 09/08/2021)

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Globally, there are now **12 million passenger EVs** (approx. 1% of the fleet) on the road, and electrification is spreading to other road transport segments. The global prediction for 2025 is 54 million passenger EVs. China and Europe will continue to be the leading EV markets until 2025, owing to **vehicle CO_2 regulation in Europe**, fuel economy rules, and the new-energy-vehicle credit system in China. Changes in policy in the United States will have a limited impact in 2021 but should boost adoption in 2022 and beyond as more enticing local models, notably in the pick-up truck class, hit the market.[5]

In the EU, electrically-chargeable vehicles accounted for **10.5%** of all new passenger car registrations in 2020 (**1 045 831 units**), compared to a 3.0% market share the year before and only 1,4% back in 2017 and 1,9% in 2018. Battery electric vehicles (BEVs) made 5,4% and plug-in hybrids (PHEVs) 5,1%. Stimulus packages introduced by governments to boost demand, following the impact of COVID-19 on car sales, sought to stimulate alternatively-powered vehicles in particular, further driving demand for low and zero-emission cars.[6,7]

During the second quarter of 2021 (see **Figure 2** and **Figure 3**), the trend continued, and registrations of BEVs in the EU reached **210,298 cars** and a **7,5% share**. The second quarter of 2021 was even better for PHEVs, with registrations climbing to 235,730 units and an 8.4 percent market share.[8] **16 cars out of 100** registered in the EU are thus electrically chargeable now.

[5] *BloombergNEF. Electric Vehicle Outlook 2021.* https://about.bnef.com/electric-vehicle-outlook/ (accessed on 09/08/2021)
[6] *ACEA statistics.* (2020). ACEA https://www.acea.auto/fuel-pc/fuel-types-of-new-cars-electric-10-5-hybrid-11-9-petrol-47-5-market-share-full-year-2020/ (accessed on 10/08/2021)
[7] *ACEA statistics.* (2021). ACEA. https://www.acea.auto/figure/fuel-types-of-new-passenger-cars-in-eu/ (accessed on 10/08/2021)
[8] *ACEA statistics.* (2020). ACEA https://www.acea.auto/fuel-pc/fuel-types-of-new-cars-battery-electric-7-5-hybrid-19-3-petrol-41-8-market-share-in-q2-2021/ (accessed on 10/08/2021)

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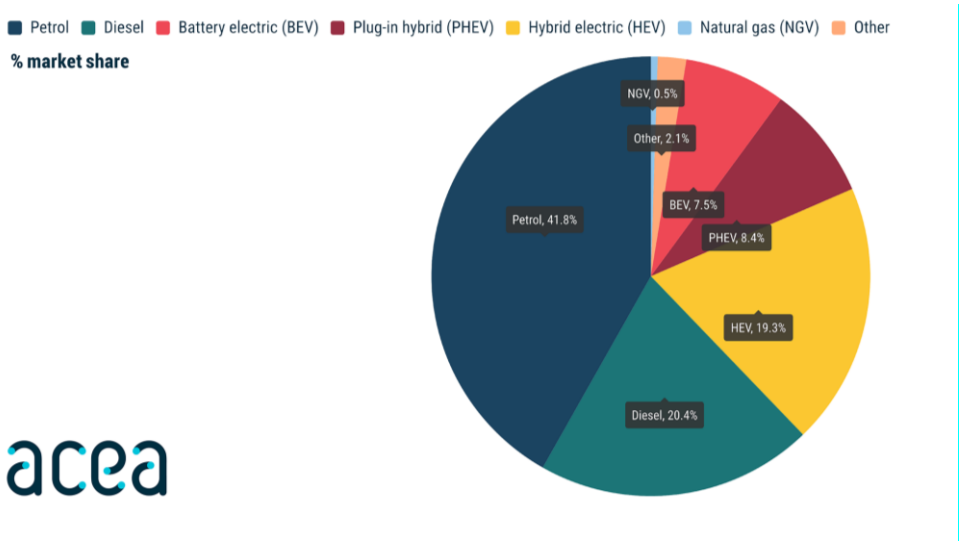

Figure 2: Registrations of passenger cars by fuel type in the 2nd quarter of 2021 in the EU

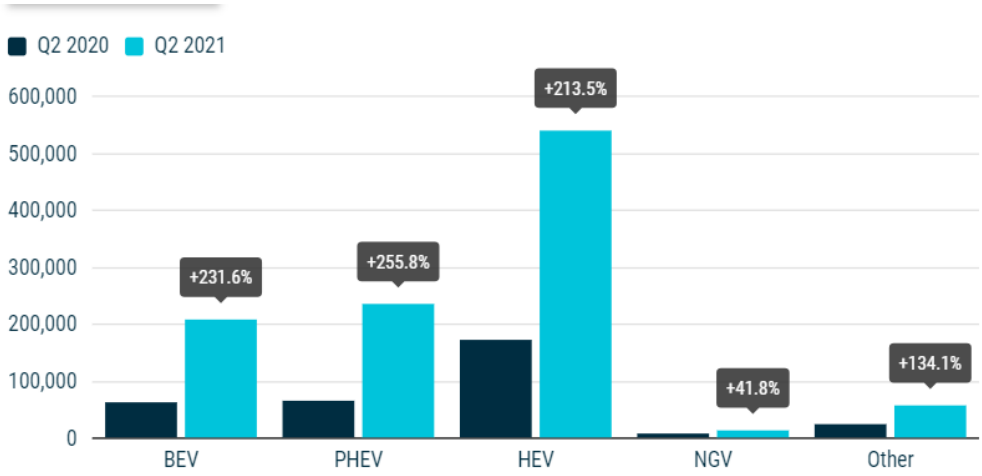

Figure 3: New passenger cars registrations in the EU by alternative fuel type in Q1 of 2020 and 2021

With more and more electric vehicles on the roads, demand for competencies and skills, even specific job roles related to battery mobile applications, has emerged and will rise. This demand is becoming prominent first in the markets where the number of electric vehicles registered and/or their share in the fleet is currently the highest (like **Western and Northern Europe** – Norway, Sweden, Denmark, Finland, the Netherlands, Germany, France, etc.[9]), but will be continuously spreading to the whole Europe.

[9] *ACEA statistics.* (2021). ACEA https://www.acea.auto/files/ACEA_progress_report_2021.pdf#page=6 (accessed on 10/08/2021)

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Appropriate charging infrastructure is necessary to respond to customers' needs and encourage demand for electric vehicles in Europe. Again, relevant skills and competencies are required to build and operate the charging stations, while most of them in the EU are currently located in three countries (the Netherlands, France, and Germany), number four and five being Italy and Sweden.[9]

Based on recent Batteries Europe and EIT RawMaterials/Fraunhofer position papers[10,11], it seems significant development on the system level is required, among others in product integration parts of the value chain. For example, in the automotive industry (including repair and maintenance of vehicles), with a large workforce already working in the field, it is challenging to **reskill employees** with a mechanical background to electrical applications or to find sufficient personnel, e.g. with professional education in the field, as also shown by ALBATTS findings.[12] Knowledge and skills in the **application/use phase** of the batteries, their operating principle, and **safety** will become increasingly important in the future. Knowledge of battery second life, recycling, and cross-cutting topics such as environmental aspects, digitalization, IT, business models, and circular economy will also be crucial.

Electrification of the Maritime Fleet

Europe is the dominant **global leader** in the electrification of vessels, as demonstrated in **Figure 4** below.

[10] *Batteries Europe. Education and skills position paper. 18.11.2020.* https://ec.europa.eu/energy/sites/default/files/documents/education_and_skills_task_force_position_paper.pdf (accessed on 30/06/2021)
[11] *EIT RawMaterials, Fraunhofer. Future Expert Needs in the Battery Sector, Report March 2021.* https://eitrawmaterials.eu/wp-content/uploads/2021/03/EIT-RawMaterials-Fraunhofer-Report-Battery-Expert-Needs-March-2021.pdf (accessed on 30/06/2021)
[12] *ALBATTS - D5.3 Future Needs Definition for sub-sector IMBA - Release 1.* (2020). ALBATTS. https://www.project-albatts.eu/Media/Publications/12/Publications_12_20210226_11248.pdf

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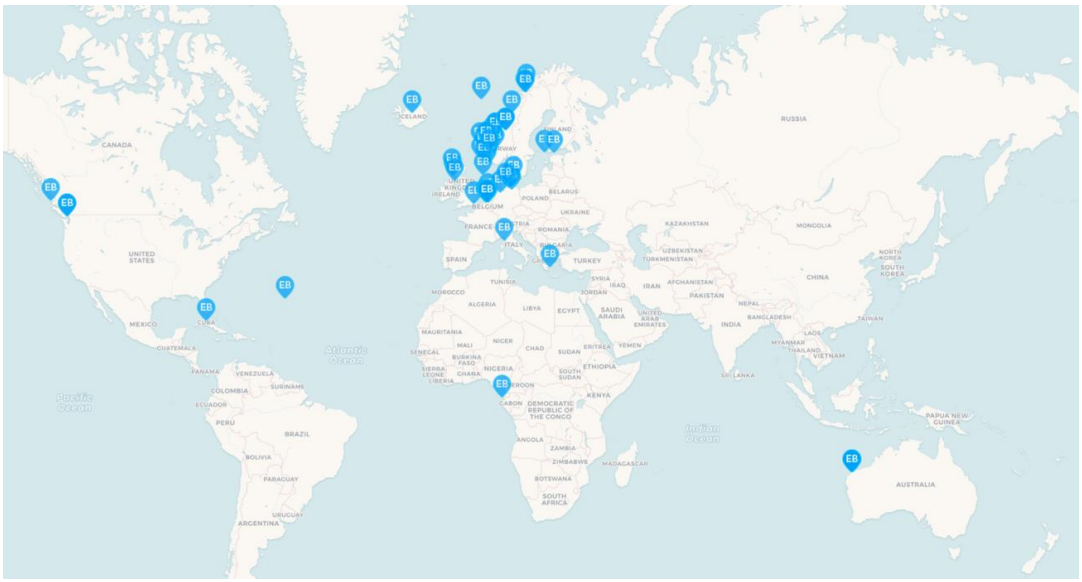

Figure 4: AIS – Positions of ships with batteries installed[13]

The main driver behind this development is EU policies and support programmes, combined with IMO regulations. Even stronger EU and regional policies and programmes will further strengthen this trend.

The maritime transport sector currently emits 820 Mt CO_2, some 2.3% of global emissions. According to forecasts[13], this will decrease to around 600 Mt by 2050, accounting for about **3.5% of global emissions**. Maritime transport is seen as a hard-to-abate sector since direct electrification is more likely to be viable only in the **short-sea segment** and few low- and zero-carbon fuel alternatives are available and practical now. In 2050, a large percentage of natural gas, ammonia, and other low- and zero-carbon fuels can be expected (see **Figure 5**), but further work is needed to bring emissions down to levels below those currently predicted.

[13] *DNV Alternative Fuels Insight, (May 2021).* https://www.dnv.com/services/alternative-fuels-insight-128171 (accessed on 19/08/2021)

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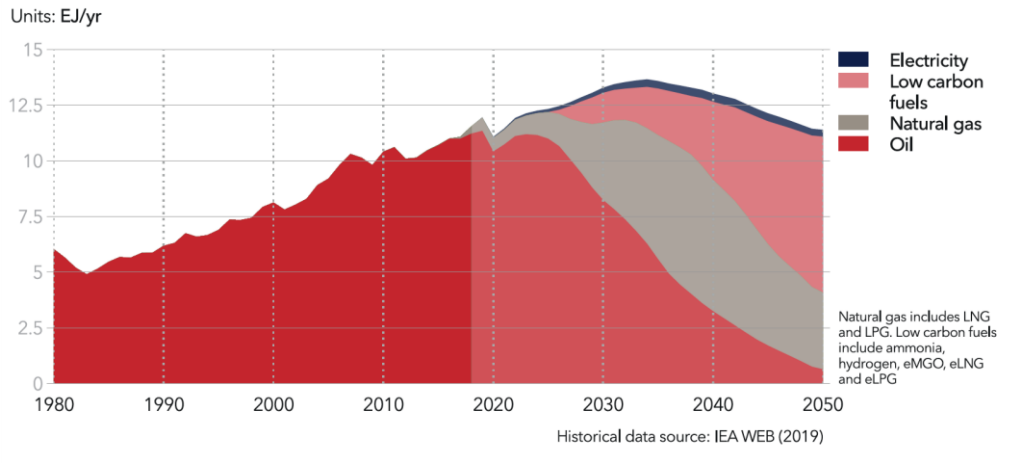

Figure 5: World maritime subsector energy demand by carrier[13]

As can be observed from **Figure 6** and **Figure 7**, large batteries are making their way into many different vessel segments. Car and passenger ferries are the most significant segments, but the breadth of market segments is continuously increasing. Interestingly enough, Asahi is constructing a fully electric coastal service **oil carrier** with 3.5 MWh of batteries.[14]

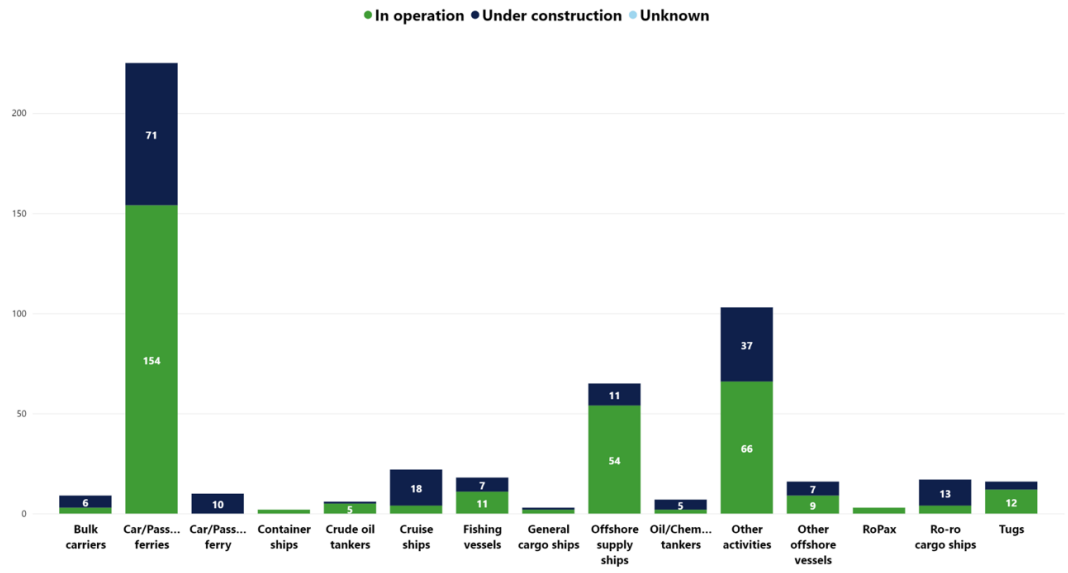

Figure 6: Battery installations on ships. Hybrid & full electric[15]

[14]P. Ayad (2021, February 20). *Soon an electric tanker with a huge 3.5 MWh battery.* Www.Dodsee.Com. https://www.dodsee.com/2021/02/soon-electric-tanker-with-huge-35-mwh.html (accessed on 21/08/2021)
[15]*Maritime Battery Forum*. (2021). Maritime Battery Forum. https://www.maritimebatteryforum.com/ (accessed on 25/08/2021)

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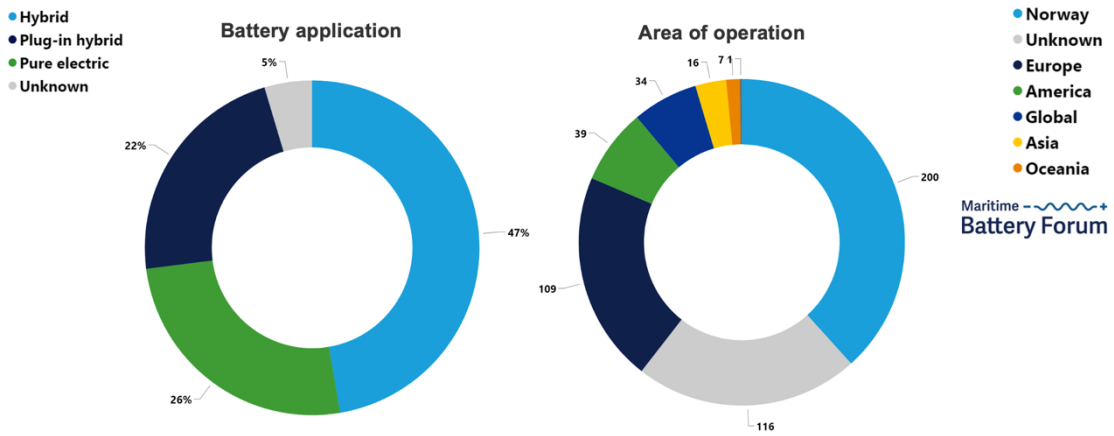

Figure 7: Share of battery application and geographical distribution[15]

With battery propulsion offering elimination of local emissions, low noise & vibration operation, lower cost, and operational advantages in the form of redundancy in propulsion, giving a lowered risk of loss of propulsion and manoeuvrability, the maritime battery market is set for **substantial growth** in the years to come.

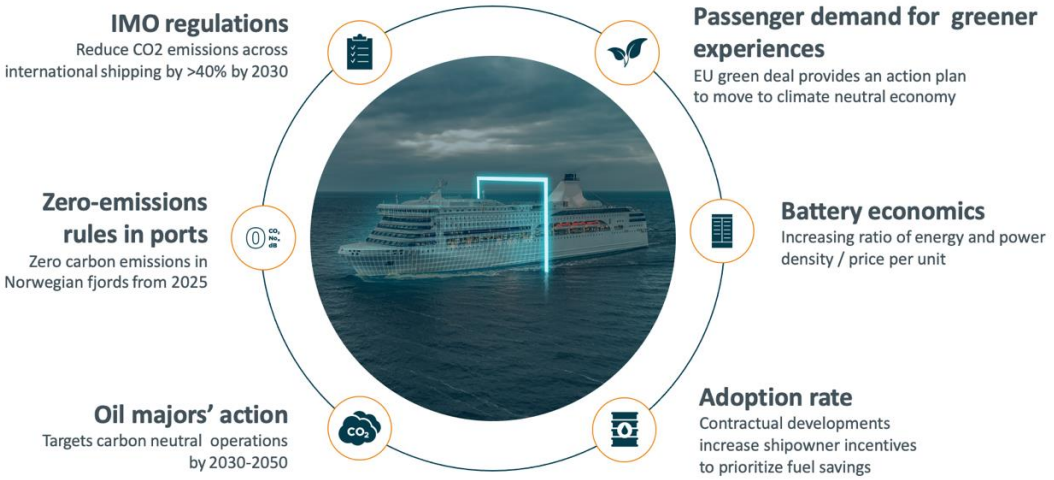

Figure 8: Numerous tailwinds behind the electrification of shipping[16]

[16]Corvus Energy internal analysis

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Methodology

This report covers the **operation, repair, and maintenance** battery value chain stage of applications in **passenger cars** (including charging stations) and **vessels** with some outreach into battery second life and battery recycling stages. Analyses of battery applications in other means of transport (such as vans, busses, trucks, scooters, bikes, and motorbikes) are expected to be included in future ALBATTS reports.

The report contains a set of **trends** that were identified within the ALBATTS project.[17] Trends related to the mobile applications of batteries (passenger cars and vessels as mentioned before) are structured according to their characteristics, and their scope is described in individual sections. Trends as such were used for further mapping of skills/competencies that outline different job roles.

This process is possible due to the extensive research (continuous desk research, survey, interviews, or workshops) that has been done in the ALBATTS project, where all relevant skills and job roles were registered in the **"competence matrix"** an internal database system interconnecting skills and competencies with job roles.

Thanks to this **mapping process**, where multiple skills were mapped to multiple trends, it is possible to see a link between trends and available skills/competence and thus job roles in the database and see which job roles or skills/competencies are influenced by or are related to different trends.

This is visualised in two different ways:
(1) **treemap** shows a set of skills - the more frequently the skills occur, the more area they cover. This was done for the sector-specific and cross-sectoral skills/competencies concerning each trend. The occurrence is calculated based on the significance of the job roles, which is described in the next point. In some cases, insufficient data was available; therefore, only cross-sectoral competence mapping was possible.

[17]Trend, in the ALBATTS project, is a concept to which different skills/competence or knowledge elements are mapped. The trend can represent a set of activities, drivers of change, or areas of interest that are relevant within the selected scope (battery application sub-sector in ALBATTS context), such as maintenance of electric vehicles, battery integration, engineering, etc.

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(2) **word cloud** visualisation is used for the significance of the job roles, while more significant job roles are showcased with bigger font sizes. This significance rating is done by analysing the skills/competence to trend mapping and selecting all job roles relevant for the trend scope and composed of this skill. This enables us to see how frequently different job roles will occur per trend.

Recommendations and **target groups** are identified as a last part of the trend description.

The primary source used for trends, sub-trends, and recommendations are the previous **project ALBATTS reports** – desk research, webinars, and survey[18] but it is also based on specific **knowledge** of project partners involved.

This is the **first report** in a series of three ALBATTS sectoral intelligence reports for mobile applications. The findings and recommendations need further **verification and specification** within upcoming ALBATTS project rounds of activities, such as the next desk research works, webinars, and other activities. We plan to update findings and expand the scope to other applications or other battery value chain steps in the next reports.

The report will be used as a **partial input** to the first overall report under the ALBATTS WP3 – Sectoral Intelligence working group - due by the end of November 2021, which will also cover other parts of the **battery value chain** from the extraction and processing of minerals to the secondary use or recycling of batteries. Therefore, the **WP3 report** will represent the main sectoral intelligence deliverable.

[18]Deliveries D5.1, D5.2 and D5.3 available at https://www.project-albatts.eu/en/results

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1 EV Battery Servicing, Repair and Dismantling

This category contains activities and trends related to increasing numbers of trained personnel needed in servicing, maintenance, repair, and disassembly of **batteries installed in electric passenger vehicles (EVs)**.

In the following text, these sub-trends are discussed in more detail:

- Servicing, Repair, and Maintenance of Electric Vehicles and EV Batteries
- End of Life - Dismantling of Batteries
- Adaptation of Dealerships, Service, and Repair Shops

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1. 1 SERVICING, REPAIR AND MAINTENANCE OF ELECTRIC VEHICLES AND EV BATTERIES

The car repair shops that we know today will gradually change due to the **lower service needs** of EVs (no need to exchange motor oil and various filters as in the case of internal combustion engines; less moving parts; also brakes wear less due to regenerative braking) and, at the same time, **higher qualification** requirements linked to EV battery and, electronics.

A car electrician/car mechanic with electro technical education and working experience or special service training is required to allow employees to repair EVs - especially when the car is **damaged** following a collision or signaling damage to the battery.

Battery **servicing** might include, e.g. disconnecting and securing the battery to prevent unintentional connections, making sure that the cables are "dead", reconnecting the battery after repair, battery **diagnostic**, fixing or replacing faulty parts, or **replacement** of the whole battery pack (by new or used battery cells/packs). However, replacing the battery pack is relatively expensive and does not seem likely to occur very often.

As indicated above, electrotechnical education with certain years of working experience or specific **professional training** concerning high voltage systems in addition to car mechanic qualification together with at least basic IT skills is needed. In addition, many electric vehicles also contain different mixtures of mostly lightweight materials, which require special repair techniques.[19]

1.1.1 Skills Agenda

Sector-specific and cross-sectoral competencies relevant to this sub-trend are visualised below. Job roles that are composed of mapped skills are then shown in the word cloud.

[19] van Barlingen, W. (2020, December 16). *How to handle repairs of electric vehicles*. Fixico Insights. https://fixico-business.com/blog/repairing-electric-vehicles/ (accessed on 22/08/2021)

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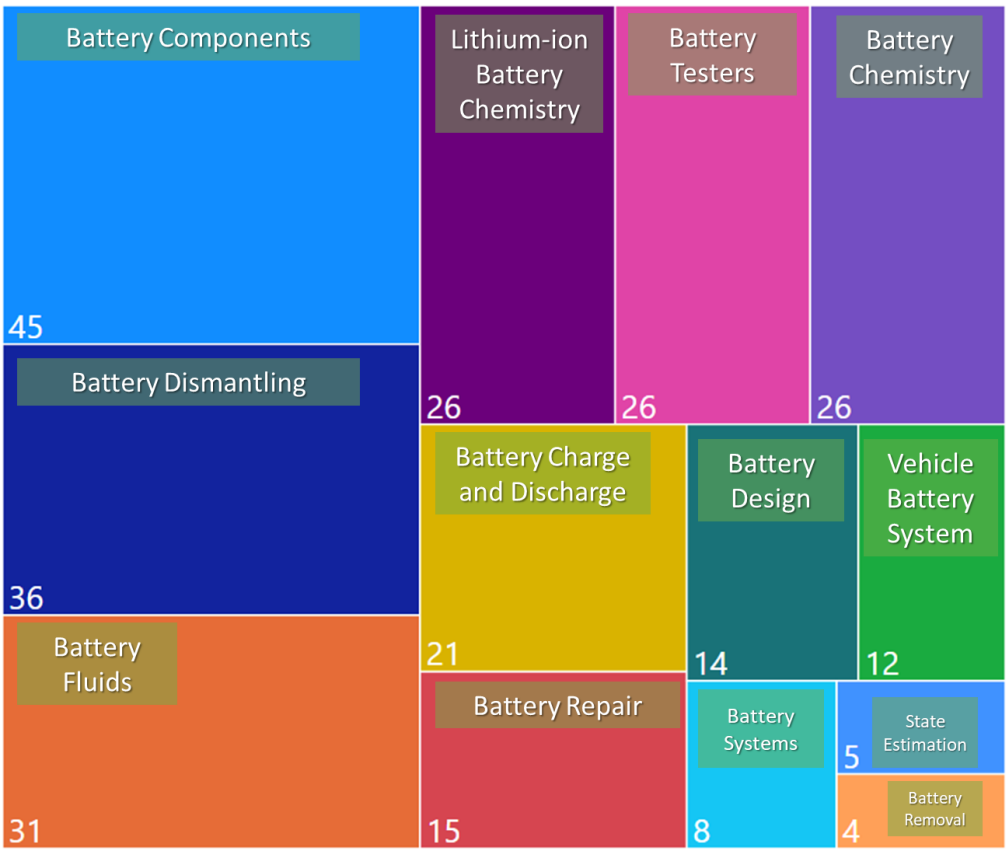

Figure 9: Sector Specific Competence

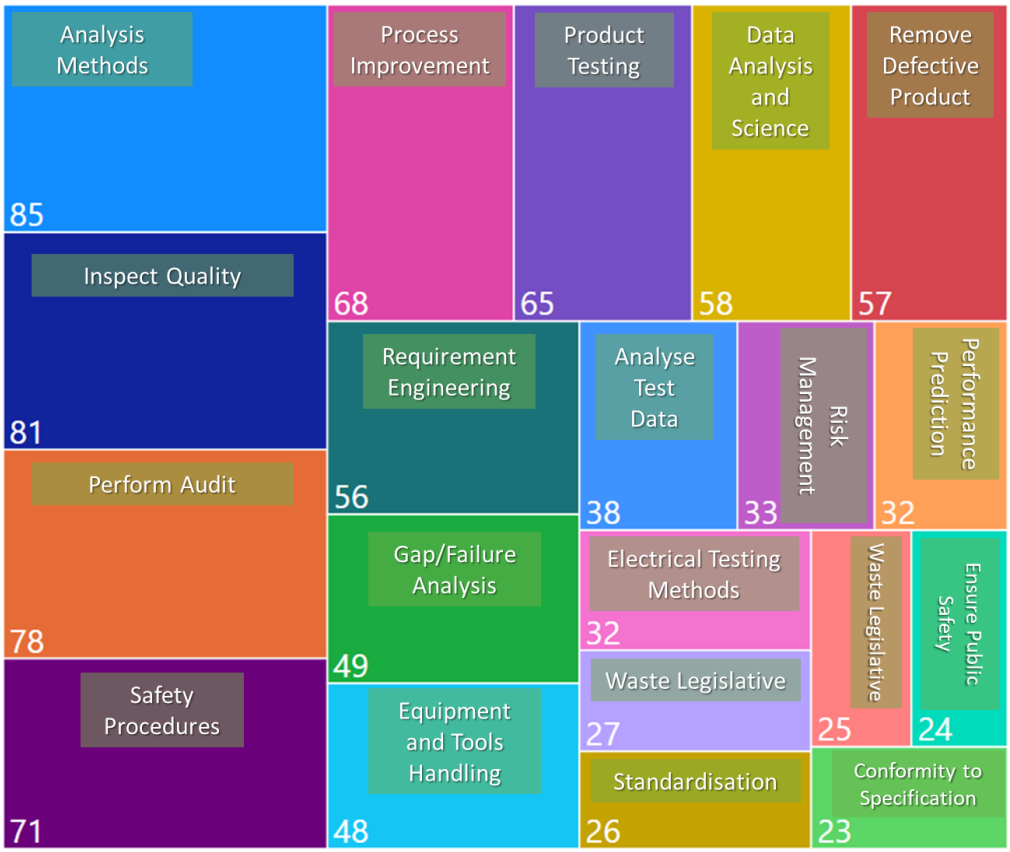

Figure 10: Cross-sectoral Competence

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Figure 11: Job roles relevant to servicing, repair, and maintenance of electric vehicles and EV batteries

1.1.2 Recommendations and Actions

- Skills and competence for EV servicing, repair, and maintenance needed to be strengthened include these areas:
  - EV and battery diagnostics and repair in general
  - High voltage competence and qualification
  - Battery charge and discharge
  - Battery management systems
  - Safety
  - Related standards and regulations knowledge

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- Gaining **high voltage** qualification can typically take at least a year, but the market will need the servicing personnel earlier and in large numbers. Therefore, introducing **fast-track training** for car mechanics taking e. g. three weeks for specific basic and strictly defined high voltage (HV) operations + training concerning basic **IT skills** (diagnostics, remote servicing, etc.) can be recommended.
- This situation might require changes to the legislation in some countries, e. g. in the area of **occupational safety**[20] – information on the situation in the different EU Member States must be gathered; a **common approach** by the EU Member States coordinated at the EU level could be beneficial.
- The situation with a potential lack of HV qualified car mechanics is to be addressed **rather urgently**, particularly in parts of the EU with the highest pace of electrification of the vehicles, such as Western or Northern Europe.
- Attracting experts for EV repair and maintenance from countries outside the EU might be helpful as well.
- Training provided for authorised service shops by **vehicle manufacturers** could serve as best practice. Developing and implementing specialised manuals for training and training provided using augmented reality has proved to be effective.

1.1.3 Target Groups

Car electricians, car mechanics, authorised and independent car repair shop owners and operators, legislators and occupational safety authorities.

[20] As in the case of the Czech Republic; the so called professional qualification will be recognised as sufficient to allow the car mechanics working with high voltage.

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1.2 END OF LIFE – DISMANTLING OF BATTERIES

Dismantling of batteries at the end of their life or the **end of life** of whole EVs, after a crash, or when the vehicle's condition does not allow its further operation also requires trained personnel.

The relevant activities may include discharging the batteries, disassembling the battery pack and modules, diagnosing their State of Health (SoH), collecting and sorting the batteries for repurposing for a second life, or recycling.

When dismantling the batteries, there are several **risk factors** to be taken into account: the possibility of overheating, fire, the release of gases, instability and short circuit. If the battery is unstable, special measures need to be applied, including **deep discharging** of the battery before dismantling.

Once the battery has been fully dismantled, cells that show no deviation from the ambient temperature can be **safely stored**. Cells that show a deviation will be stored in a specially secured area that is constantly monitored.[21]

The average lifespan of cars can vary from 8.0 to 35.1 years, with an average of 18.1 years in Western and 28.4 years in Eastern European countries.[22] Therefore, demand for the above-described activities can **increase significantly in several years**, be it in countries with developed EV markets or countries to which second-hand EVs are exported.

1.2.1 Skills Agenda

Sector-specific and cross-sectoral competencies relevant to this sub-trend are visualised below. Job roles that are composed of mapped skills are then shown in the word cloud.

[21] *Dismantling EV batteries*. (2021). Sortbat. https://www.sortbat.be/expertise/dismantling (accessed on 22/08/2021)
[22] Held, M., Rosat, N., Georges, G. *et al.* Lifespans of passenger cars in Europe: empirical modelling of fleet turnover dynamics. *Eur. Transp. Res. Rev.* 13, 9 (2021). https://doi.org/10.1186/s12544-020-00464-0, last accessed 12/8/2021

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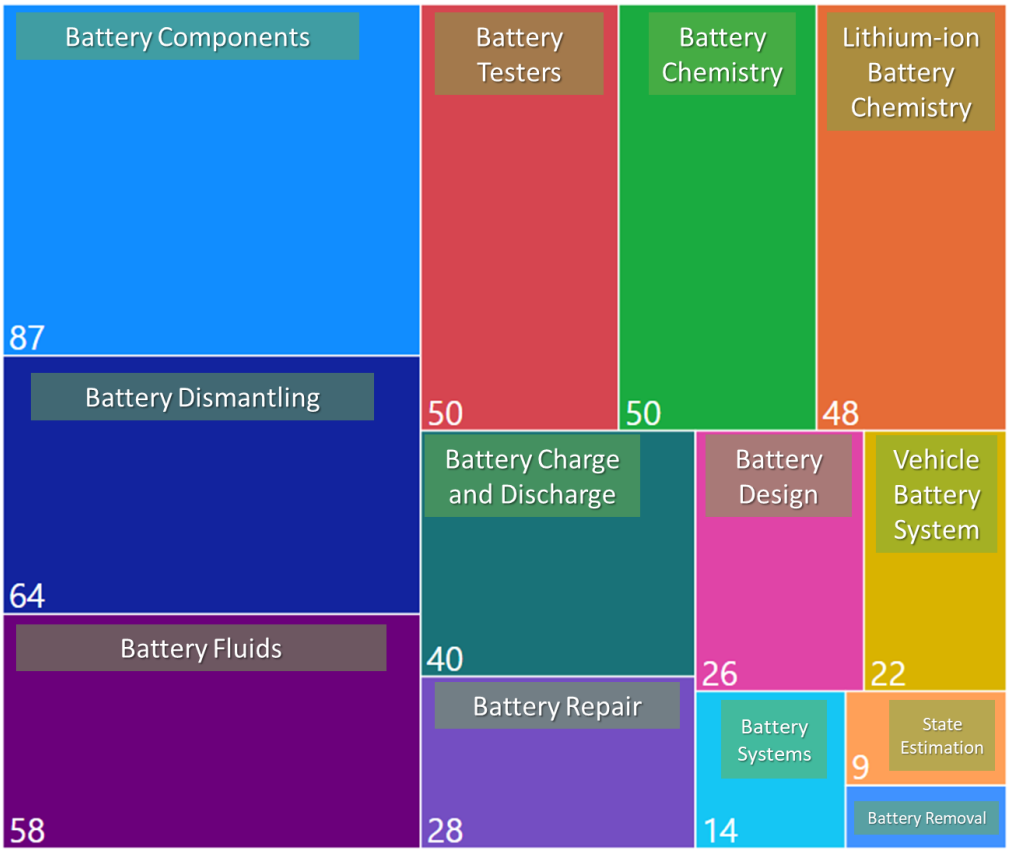

Figure 12: Sector Specific Competence

Figure 13: Cross-sectoral competence

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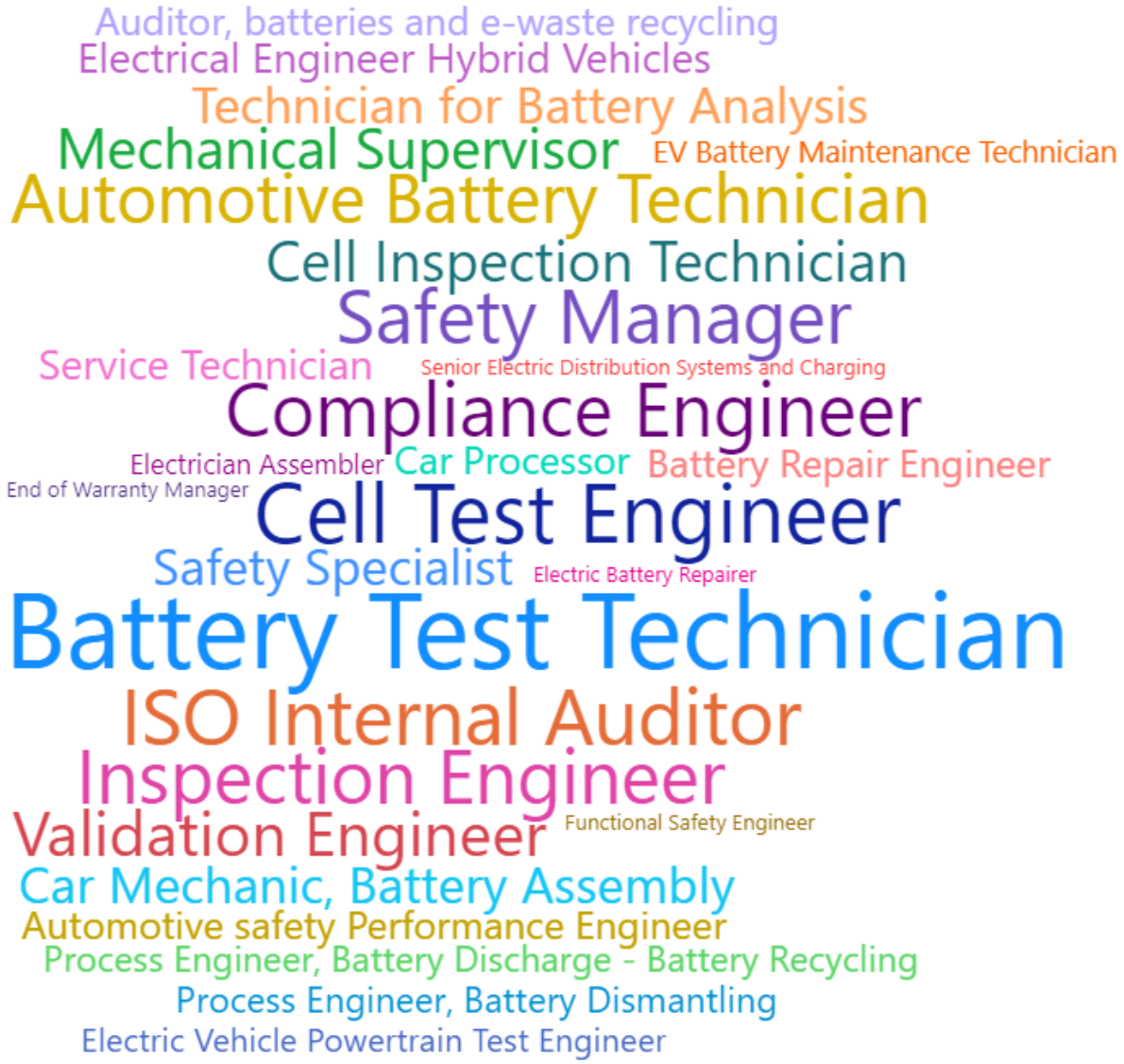

Figure 14: Job roles relevant to the dismantling of batteries

1.2.2 Recommendations and Actions

- Introducing relevant training to achieve **appropriate numbers** of qualified personnel within the suitable timeframe respecting the average lifespan of the vehicles.
- Strengthening of competence for **battery dismantling** is needed, mainly: high voltage competence, qualification and development, and proper procedures and correct instructions.
- Strengthening the knowledge to ensure **compliance** with safety and environmental **legislation**, standards, and legislation, including those regulating **transport** of (used) batteries.

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- **Cooperation** between second life/recycling of batteries entities and battery manufacturers/integrators should be strengthened.
- **Research and development** competencies should be further prioritised in areas of:
  - Recycling
  - Refurbishment of used batteries
- Furthermore, the following challenges concerning second life batteries need to be taken into consideration and tackled on a general level:
  - Data availability and security
  - Battery design for second life and recycling
  - Used batteries collection
- There is also a need to strengthen competencies in **digitalisation** and **traceability** of the battery lifecycle.

1.2.3 Target Groups

Car electricians and mechanics, dismantling, sorting and recycling companies, legislators.

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1.3 ADAPTATION OF DEALERSHIPS, SERVICE AND REPAIR SHOPS

Dealerships, service and repair shops for EVs, both authorised by the OEMs or independent, need to be equipped adequately for dealing with EVs, batteries, and high voltage systems. **Charging infrastructure** is being placed within some of the premises.

The charging solution can be combined with **renewable energy** (e.g. photovoltaics) and **energy storage** systems so that customers can get their EVs fully charged after the repair and the solution is economically and environmentally sustainable.

Safety aspects of EVs placed inside a building, possibly together with the charging and energy storage devices, must be considered. Taking care of a damaged EV/battery, a place with specific properties (such as an open-air parking area, a sufficient distance away from other vehicles, buildings, flammable objects, and flammable surfaces = "**quarantine area**") must be ensured.

1.3.1 Skills Agenda

Sector-specific and cross-sectoral competencies relevant to this sub-trend are visualised below. Job roles that are composed of mapped skills are then shown in the word cloud.

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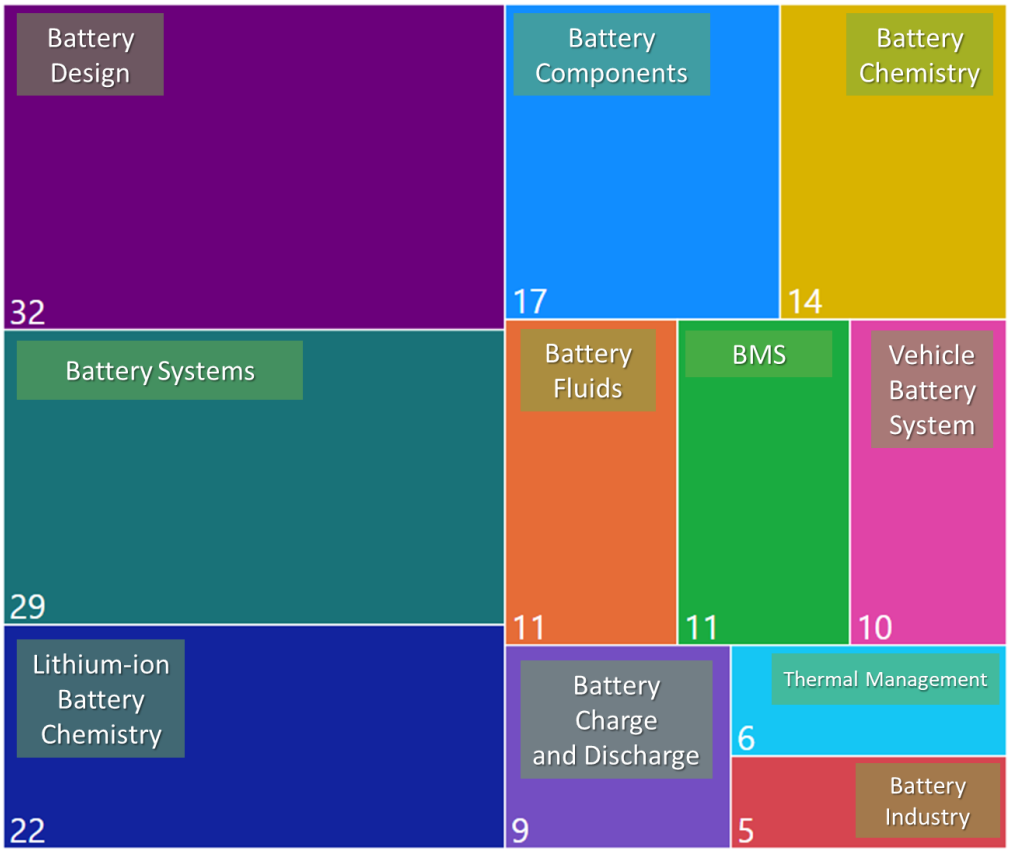

Figure 15: Sector Specific Competence

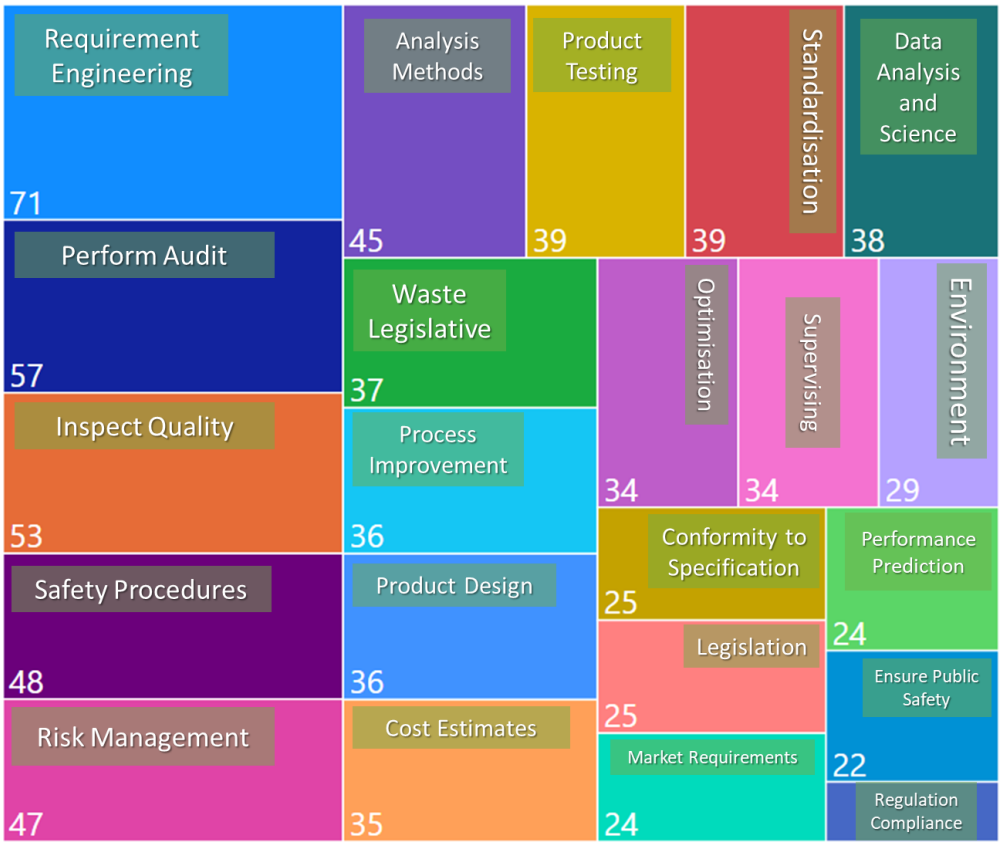

Figure 16: Cross Sectoral Competence

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Figure 17: Job roles relevant to the adaptation of dealerships, service and repair shops

1.3.2 Recommendations and Actions

- Planning and installing of the charging stations and the renewable energy/energy storage systems need to be handled by **qualified personnel.**
- Creating safety instructions and following the **safety protocol** for parking and repairing EVs with (potentially) damaged battery is crucial.
- For certain operations, the service shop staff must be instructed to use **protective equipment** such as insulated tools or high-voltage gloves.

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1.3.3 Target Groups

Car repair shop owners and operators, companies producing and installing charging stations, companies providing protective equipment for service repair shops, companies providing and implementing renewable energy/energy storage solutions.

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2 EV Customer Needs and Related Services

This category contains activities and trends related to increasing numbers of trained personnel needed in areas of **customer services** related to the operation of EVs and the batteries installed in them.

In the following text, these sub-trends are discussed in more detail:

- Advising Customers in Dealerships, Car Rentals, and Secondary Market
- Smart Charging, Fleet Management, Data Sharing Services
- Charging Infrastructure Design, Installation, and Maintenance
- Rescue Services, Roadside Assistance
- Education in Driving Schools

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2.1 ADVISING CUSTOMERS IN DEALERSHIPS, CAR RENTALS, AND SECONDARY MARKET

Dealerships and leasing companies' staff need to be trained to be able to provide the correct information to customers concerning specifics of the electrified vehicle operation, battery charging (e.g. specifics of AC and DC charging and its impact on battery, avoiding over-discharging or overcharging the electric vehicle battery which reduces battery life, charging in cold temperatures) and maintenance to ensure long battery life and trouble-free operation. Nevertheless, the relevant information shall also be included in manuals provided by car manufacturers.

Car rental companies' staff should be able to provide information on the use and charge of the electric vehicle and battery-specific instructions on how to behave in case of car damage or accident. This also concerns **shared mobility** companies. Also, financial institutions, including **leasing and insurance companies,** need to understand the essential characteristics of EVs and the batteries to introduce and provide relevant products.

Secondary market - trained personnel will be needed not only in case of sale of a new car but also within the used cars market to be able to assess the State of Health (SoH) of the batteries, evaluate its price, and re-sell it to a customer, describe its functioning, properties and advise on its operation.

2.1.1 Skills Agenda

Cross-sectoral competencies relevant to this sub-trend are visualised below (mapping for sector-specific competencies was not possible due to lack of data). Job roles that are composed of mapped skills are then shown in the word cloud.

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Figure 18: Cross Sectoral Competence

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Figure 19: Job roles relevant to advising customers in dealerships, car rentals, and secondary market

2.1.2 Recommendations and Actions

- Providing methodological guidance – manuals and training to car dealerships, car rentals, shared mobility companies – is necessary to ensure the quality of advising to customers. Car manufacturers' booklets or their involvement in training material creation for the staff in dealerships could be helpful.
- Manuals and training are indispensable also to leasing or insurance companies so that they can assess the EV´s value and its development.

2.1.3 Target Groups

EV first and second-hand dealers, both authorised and independent, car rentals, leasing companies, insurance companies, used cars dealerships, EV importers, shared mobility companies.

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2.2 SMART CHARGING, FLEET MANAGEMENT, DATA SHARING SERVICES

Smart charging where EVs, charging stations, and charging operators exchange live data such as State of Charge (SoC), vehicle position, or data from the grid can be used to optimise energy consumption and allow grid peak balancing.

Fleet management - the specifics of electrified vehicles, such as the still limited battery capacity and therefore limited range, longer charging time compared to the refueling of a conventional gasoline or diesel car, and insufficient charging infrastructure, open up space for new business models and services. The need to monitor and manage the state of charge of the battery is especially relevant for the management of company fleets, in which there may be tens, hundreds, or even thousands of vehicles.

To reduce the complexity of management of large EV fleets such as those belonging to large corporations, delivery services, or public authorities, some companies have been launching **online tracking services** where a (telematics) device installed in the car, GPS and mobile network combined with data from the charging station and the grid may be used for real-time monitoring and administration of electric vehicle fleets including battery State of Charge (SoC), State of Health (SoH), charging information, maintenance alerts and other relevant and potentially valuable data.

Data sharing - sharing vehicle data, including State of Charge (SoC) of an EV battery, might enable attractive **business services,** e.g. in the areas of navigation and charging. Furthermore, Sharing State of Health (SoH) and other battery-relevant data might also offer exciting business opportunities to be explored by companies with battery-qualified staff.

2.2.1 Skills Agenda

Sector-specific and cross-sectoral competencies relevant to this sub-trend are visualised below. Job roles that are composed of mapped skills are then shown in the word cloud.

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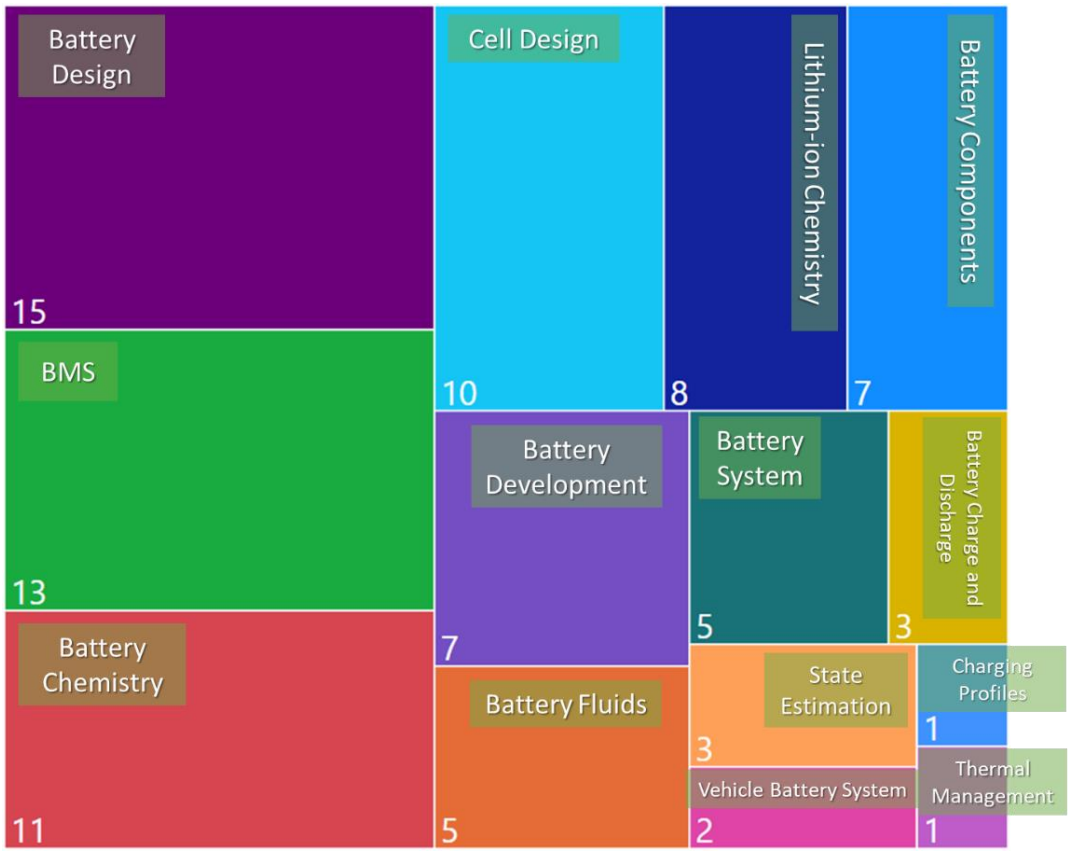

Figure 20: Sector Specific Competence

Figure 21: Cross-sectoral Competence

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Figure 22: Job roles relevant to smart charging, fleet management, data sharing services

2.2.2 Recommendations and Actions

- Strengthening combined competencies in the area of battery and charging systems, business and software development, telematics, and grid functions.

2.2.3 Target Groups

Charging station and grid operators, telematics, business, and software development companies.

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2.3 CHARGING INFRASTRUCTURE DESIGN, INSTALLATION, AND MAINTENANCE

A dense charging network for EVs shall be installed across the EU in private, semi-public (shopping centres, hotels...), corporate or public places. This requires skilled personnel for charging **infrastructure** design, installation, and maintenance that also needs to be aware of the characteristics of EVs and their **batteries** to ensure proper ways of charging.

Infrastructure building can often be quite a **complex project**, starting with feasibility studies, location planning, grid considerations, followed by preparation, installation and operation, maintenance, and providing advisory services, up to training and guidance to staff and customers. **IT solutions** are also part of the charging infrastructure and its payment systems.[23]

Battery swapping concepts aim to replace the need to charge the EV by completely replacing the battery pack using a mechanized device. They currently seem to be a **dead-end** for passenger cars, partly due to the different vehicle and battery designs of different types of EVs and warranty issues.

To improve customer comfort, technical solutions for static and dynamic **wireless charging** are being explored.

2.3.1 Skills Agenda

Sector-specific and cross-sectoral competences relevant to this sub-trend are visualised below. Job roles that are composed of mapped skills are then shown in the word cloud.

[23] *E.ON Drive*. (2020, December 21). E.ON Drive. https://www.eon-drive.cz/sluzby/ (accessed on 22/08/2021)

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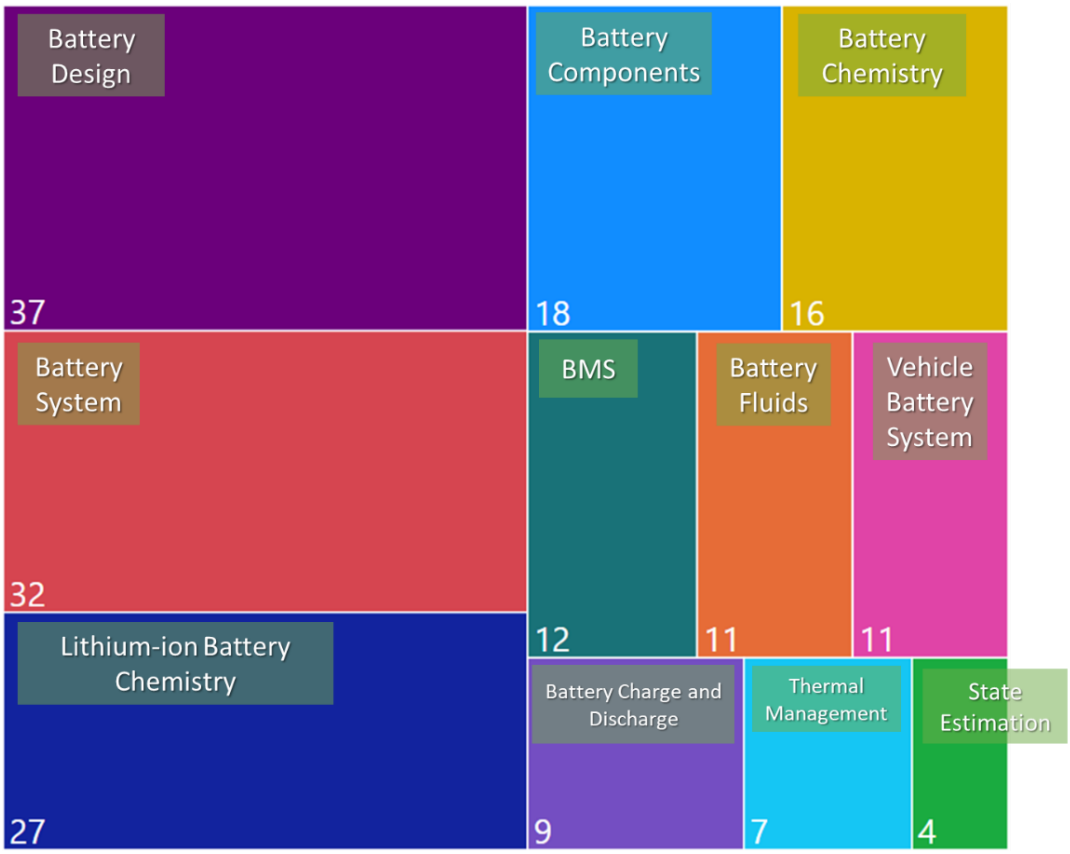

Figure 23: Sector Specific Competence

Figure 24: Cross-sectoral Competence

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Figure 25: Job roles relevant to charging infrastructure design, installation, and maintenance

2.3.2 Recommendations and Actions

- This area covers a broad range of competence - design, building permit processes, installation, operation, and maintenance of charging infrastructure in private, semi-public, and public places with the focus on battery relevant safety, IT and payment solutions as well as future charging concepts such as static and dynamic wireless charging.
- Therefore, needs for all the mentioned expertise and skills will increase and must be satisfied; otherwise, the development of charging infrastructure will not cope with the EV number delivered to the market, and, therefore, customer acceptance could be endangered.

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2.3.3 Target Groups

Companies manufacturing, installing, operating, and maintaining charging stations and possible future (wireless) charging solutions.

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2.4 RESCUE SERVICES, ROADSIDE ASSISTANCE

Rescue services - as more EVs become operational on the roads, the number of traffic accidents involving EVs is likely to rise. When it comes to EVs, one of the most significant aspects is the risk that the Lithium-Ion battery (LIB) may also **ignite** after a significant amount of time after being damaged or **reignite** after having been extinguished. This matter concerns not only **firefighters** but also those involved in handling damaged EVs through **towing** or in the **workshops.**[24,25]

First responders and **post-crash handlers** need to be aware of the possible risks posed by EVs and how to handle them. If the vehicle is rightly identified, fire rescue services can use information gathered from manufacturers´ manuals and emergency response guides or applications developed for this matter. For firefighters, for instance, knowing how to turn off the electricity in all car models and/or cut open an EV safely, is crucial.

Another important aspect is handling **gas and fluids** that can leak from batteries. Efforts to suppress LIB fires can result in a relatively large amount of contaminated water or other foam/liquid run-off material that should be **collected and disposed of** responsibly. Different projects are looking at efficient cooling agents apart from water, a fire blanket, or approaches providing easy access to extinguishing liquids into the battery pack.

Towing - while some EVs can be towed, others can only be moved on a flat-bed truck/on a platform (the electric/hybrid system may be damaged if the drive axle(s) remain(s) in contact with the road surface). It is vital to follow the EV manual provided by the vehicle manufacturer. When towing a damaged EV, the high voltage system should be deactivated, and the car shall not be in a critical condition.[26]

[24]ALBATTS. D5.1 - Desk research and data analysis for sub-sector IMBA - Release 1. https://www.project-albatts.eu/Media/Publications/4/Publications_4_20200930_12811.pdf
[25]ALBATTS. D4.3 - Future Needs Definition for sub-sector ISIBA - Release 1. https://www.project-albatts.eu/Media/Publications/16/Publications_16_20210226_153326.pdf
[26]*VDA*. (2020). VDA. https://www.vda.de/en/topics/safety-and-standards/rescue/rescue-recovery-vehicles-with-48-Volts-and-high-voltage-systems.html (accessed on 22/08/2021)

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Mobile charging services for roadside EV assistance with trained personnel can get involved if an EV **gets stuck** discharged in the middle of a journey due to incorrect planning, technical issues on the side of the vehicle, faulty or occupied charging station, or other reasons.

Mobile charging may also be needed for significant events such as **music festivals** or emergencies with many **cars stranded** (especially in winter) on motorways.

2.4.1 Skills Agenda

Sector-specific and cross-sectoral competencies relevant to this sub-trend are visualised below. Job roles that are composed of mapped skills are then shown in the word cloud.

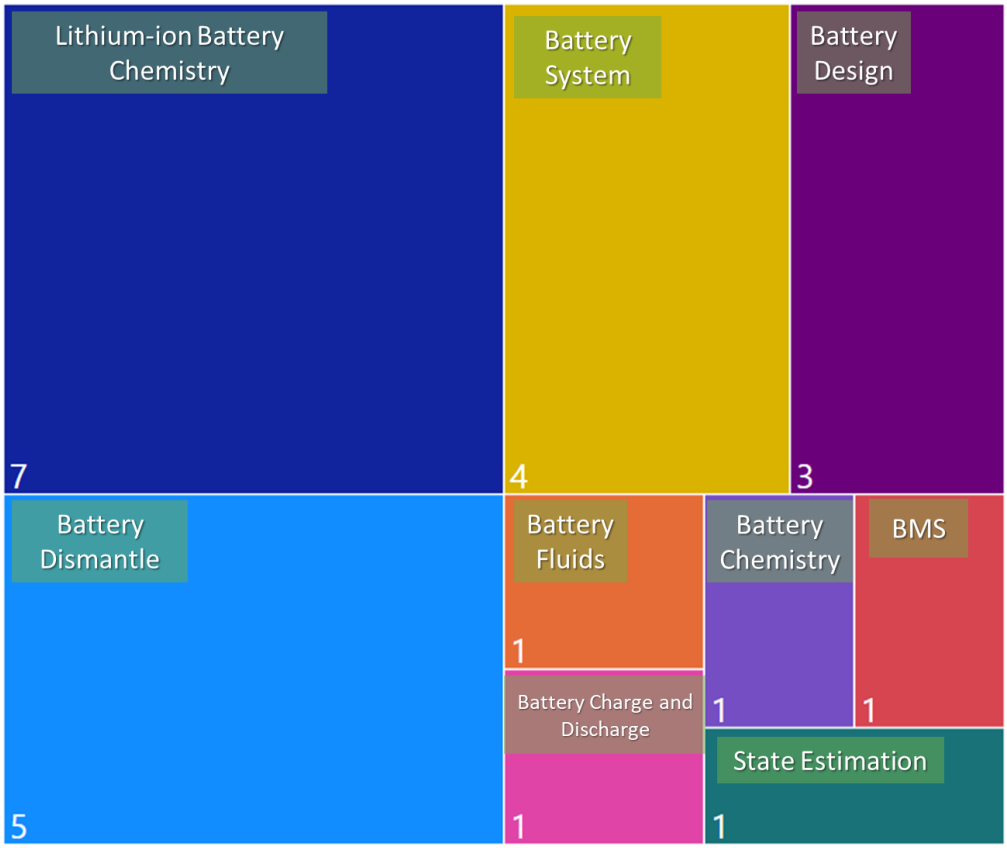

Figure 26: Sector Specific Competence

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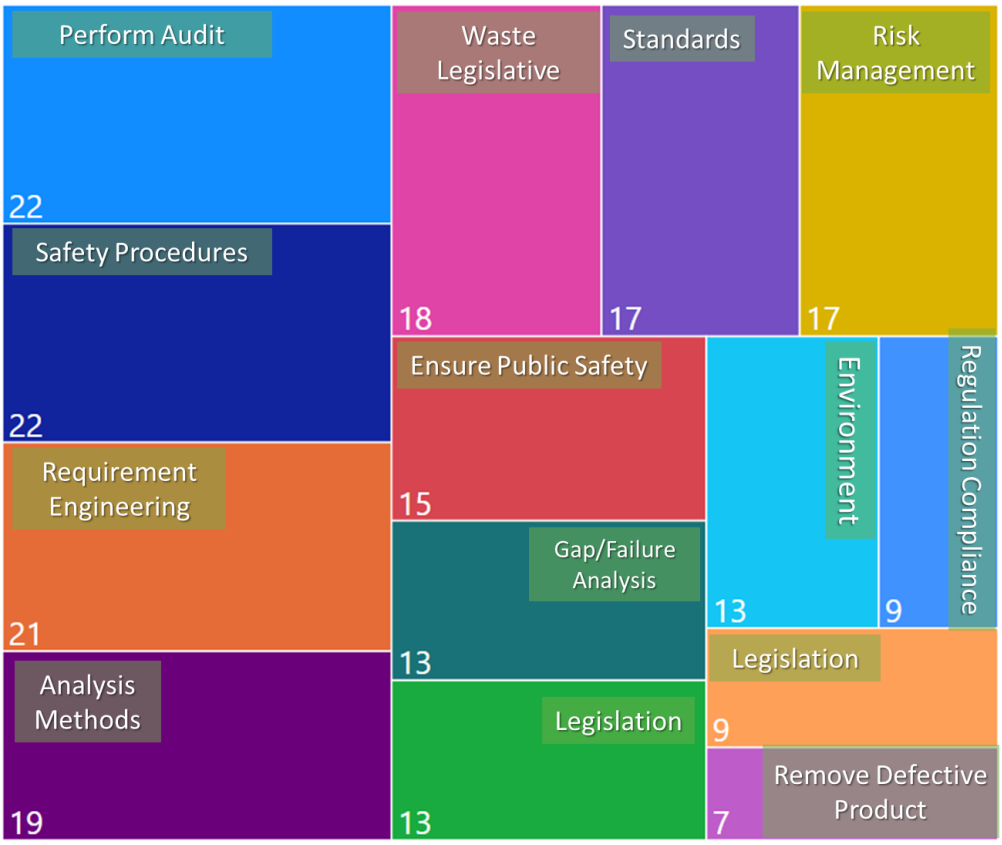

Figure 27: Cross-sectoral Competence

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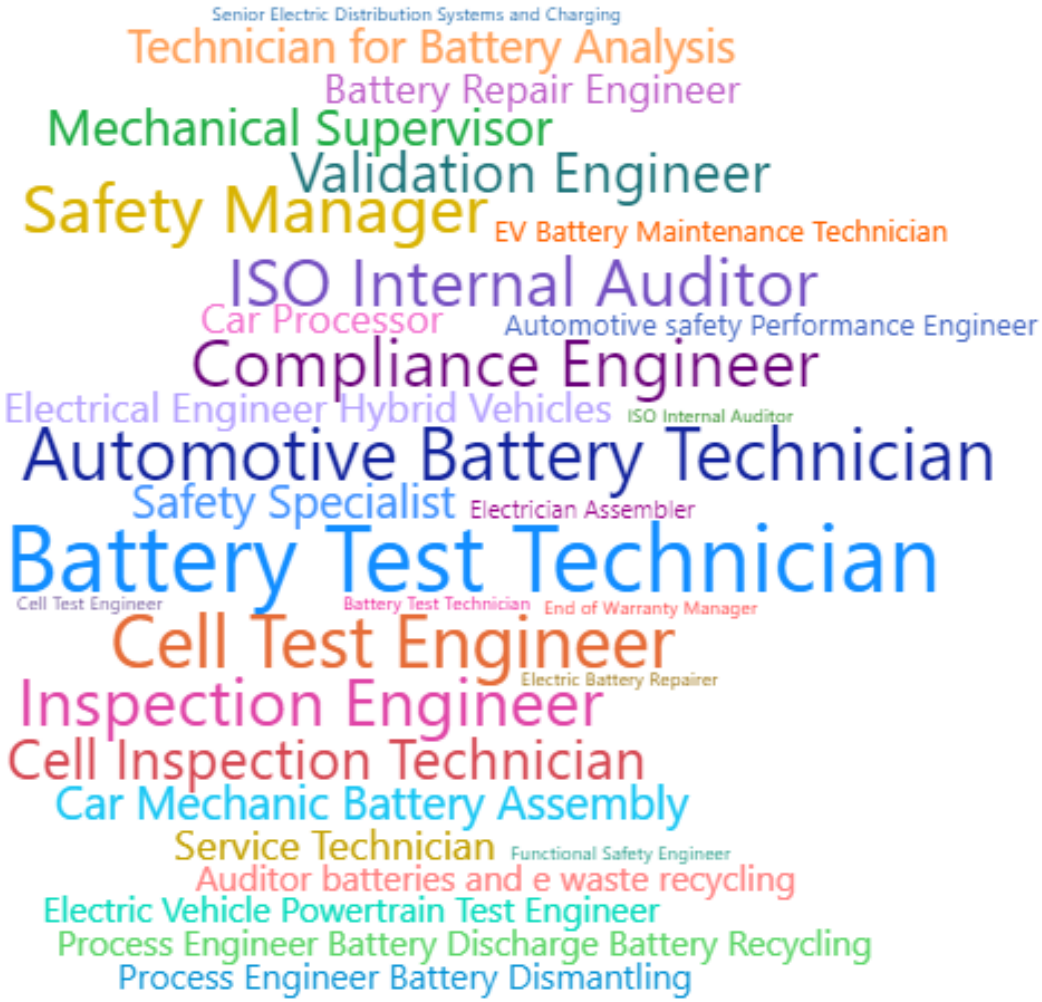

Figure 28: Job roles relevant to rescue services and roadside assistance

2.4.2 Recommendations and Actions

- Specific knowledge is required when **fire or another kind of emergency** concerning an EV occurs. There is a need for new methods, tactics, and specific training for first-responders, fire and rescue services. Cooperation at the EU or international level is vital to share best practices and create specific manuals.[27]
- Extinguishing fire of EV batteries is an important topic, where cooling agents or new approaches must be explored via **research and development** projects, also depending on future battery technologies. Education in this area increases in importance.
- **Towing** of an EV stuck on the road shall be performed by a qualified person since it can create dangerous voltages. Best practices shall be shared via manuals and training.

[27] *Emergency response on vehicles*. (2016). Emergency Response on Vehicles | CTIF - International Association of Fire Services for Safer Citizens through Skilled Firefighters. https://ctif.org/training-and-tools/emergency-response-vehicles (accessed on 11/08/2021)

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- **Mobile charging** services offer can be expected to grow. Their staff needs to have a good understanding of how batteries work.

2.4.3 Target Groups

Towing/road assistance companies/handlers, first-responders, fire brigades, ambulances, mobile charging services, repair shops workers, vehicle manufacturers.

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2.5 EDUCATION AT DRIVING SCHOOLS

Driving school **instructors** need to be trained to be well aware of the specifics of EVs so that the driving school **students** can ensure proper use, road safety, and reasonable maintenance of the electric vehicle and its battery.

Some electric cars can sometimes be driven rather **slowly**, particularly on motorways (electricity consumption in most EVs increases significantly at higher speeds) or when the electricity is **running out.** Some of the EVs may brake using recuperation **without the brake lights** unfolding. This can pose an increased risk to road safety and necessitates awareness.

Parking of combustion engine vehicles on **parking places reserved for charging** electric vehicles is, for example, a rather common bad habit of uniformed drivers.

2.5.1 Skills Agenda

Cross-sectoral competencies relevant to this sub-trend are visualised below (mapping for sector-specific competencies was not possible due to lack of data). Job roles that are composed of mapped skills are shown in the word cloud.

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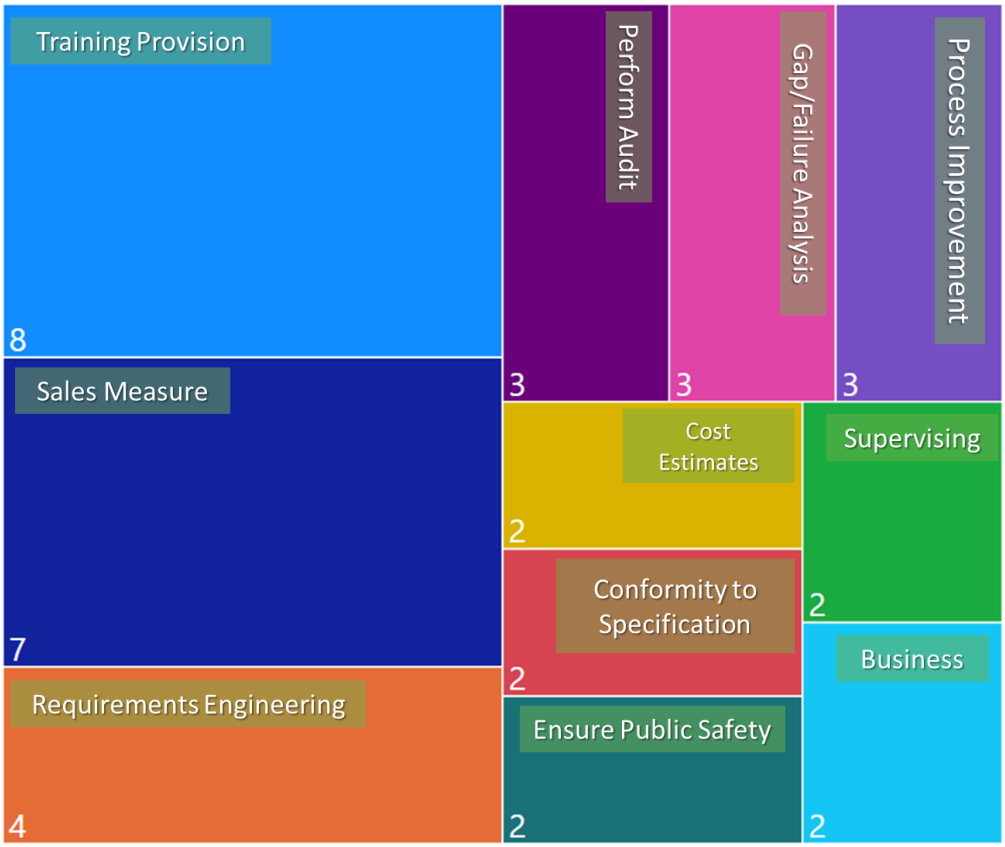

Figure 29: Cross-sectoral Competence

Figure 30: Job roles relevant to education at driving schools

2.5.2 Recommendations and Actions

- Competence within the driving schools should be updated, together with the teaching materials, and strengthened to facilitate the electrification of road transport and structural changes in the automotive sector.

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- Drivers and driving schoolteachers need to be trained to be well aware of the specifics of electric cars to ensure:
  - Proper operation, maintenance, and charging of EV
  - Road safety

2.5.3 Target Groups

Driving schools, instructors, students, legislators, road safety institutions.

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3 Autonomous Driving, Vehicle to Grid

This category contains activities and trends related to increasing numbers of trained personnel expected to be needed in technical areas of autonomous driving and vehicle to grid (V2G) concepts and services.

- Autonomous Driving
- Vehicle to Grid Concept

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3.1 AUTONOMOUS DRIVING

The electrification of vehicles is one of the **enablers** of autonomous driving. EVs seem to be easier to be driven by computers than Internal Combustion Engine (ICE) vehicles.[28] Autonomous driving has the potential in the area of **road safety** to reduce or eliminate human error, thus reducing the number of crashes, injuries, and damages and increasing the **comfort** of the passengers who would partially or wholly get rid of the need to drive the vehicle.

Autonomous Electric Vehicles will use AI, next-generation batteries, and fourth industrial revolution technologies. Legislation and regulations for self-driving cars have to be put in place.[29]

3.1.1 Skills Agenda

Sector-specific and cross-sectoral competencies relevant to this sub-trend are visualised below. Job roles that are composed of mapped skills are then shown in the word cloud.

[28]McCauley, R. (2021, April 29). *Why Autonomous and Electric Vehicles Are Inextricably Linked*. GovTech. https://www.govtech.com/fs/why-autonomous-and-electric-vehicles-are-inextricably-linked.html (accessed on 18/08/2021)
[29]PricewaterhouseCoopers. (2020). *Autonomous Electric Vehicles*. PwC. https://www.pwc.co.uk/services/sustainability-climate-change/insights/autonomous-electric-vehicles.html (accessed on 23/08/2021)

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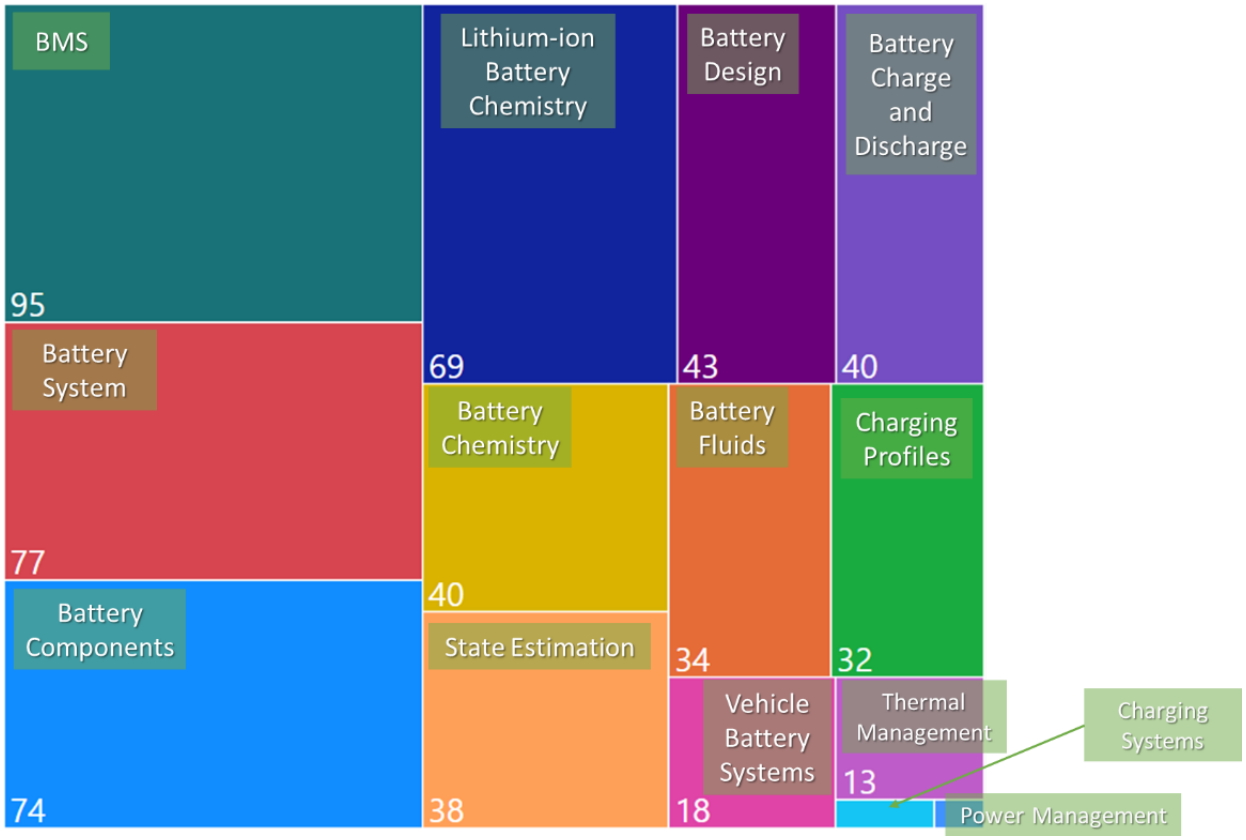

Figure 31: Sector Specific Competence

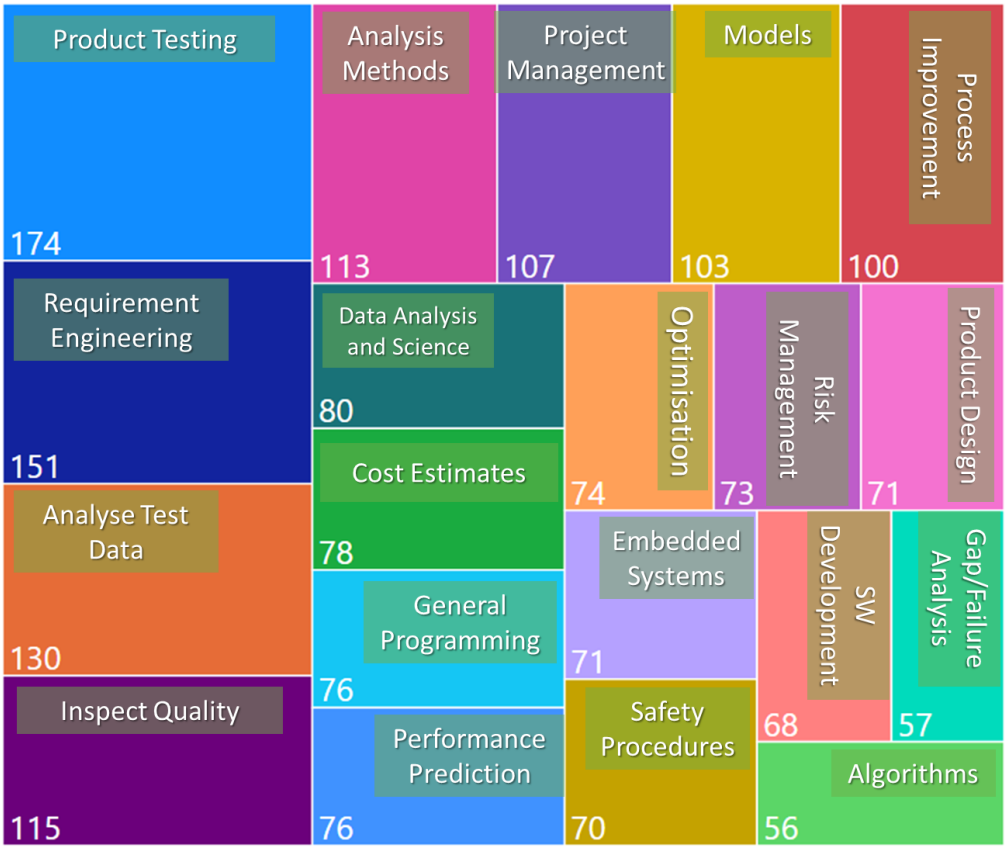

Figure 32: Cross-sectoral Competence

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Figure 33: Job roles related to autonomous driving

3.1.2 Recommendations and Actions

- The prospects for electrification and autonomous driving are bright, however, it is **difficult to determine** their impact on future battery skills needs now.
- What seems to be rather obvious already now, is that **cybersecurity skills/competence** and knowledge related to the mobile applications of batteries in electric vehicles need to be prioritised when applying concepts of autonomous vehicles.
- Security approach needs to be perceived as important and urgent – resilience to cyber-attacks, as well as customer privacy and security.

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3.1.3 Target Groups

Vehicles manufacturers, IT, cybersecurity, SW and technology companies, start-ups, R&D organisations, legislators.

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3.2 VEHICLE TO GRID (V2G) CONCEPT

New generations of EVs are expected to be able not only to receive the energy from the grid but also to send it **back to the grid** whenever needed. This can help **balance the grid**, shave-off peaks, supply energy when needed, and thus better integrate renewable resources.

It could also reduce energy costs for drivers/end consumers by e.g. using the energy stored in the EV battery to **power household** appliances and recharge the battery when the electricity supplier offers the cheapest rates.

Also, the flexibility provided by V2G means that a battery can be charged during the hours that energy is being produced by **renewable sources** (daylight in case of photovoltaics), and then that electricity can be used when solar or wind power is unavailable.[30] Thus, it will enable new business **services** and customer concepts.

3.2.1 Skills Agenda

Sector-specific and cross-sectoral competencies relevant to this sub-trend are visualised below. Job roles that are composed of mapped skills are then shown in the word cloud.

[30] *How does V2G, or vehicle-to-grid, work? - Renault Group*. (2019). Renault Groupe. https://www.renaultgroup.com/en/news-on-air/news/whats-the-deal-with-v2g-or-vehicle-to-grid/ (accessed on 23/08/2021)

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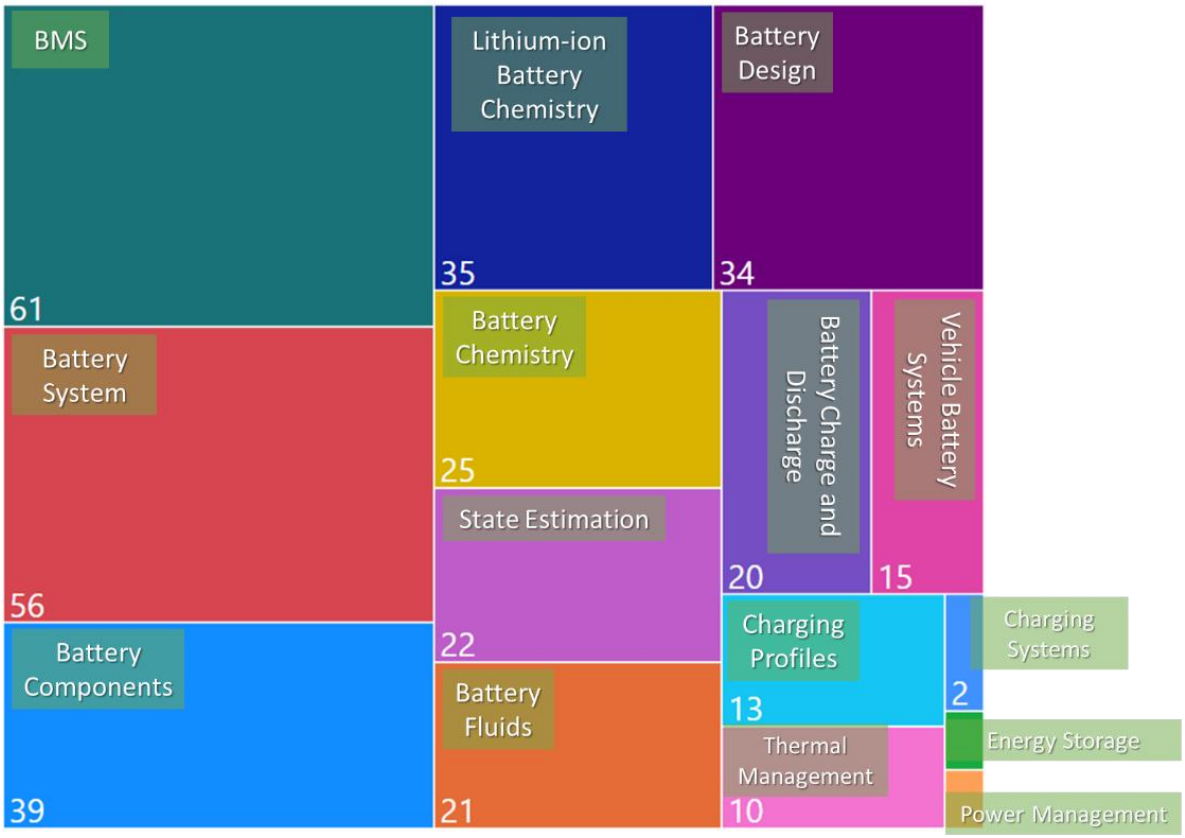

Figure 34: Sector Specific Competence

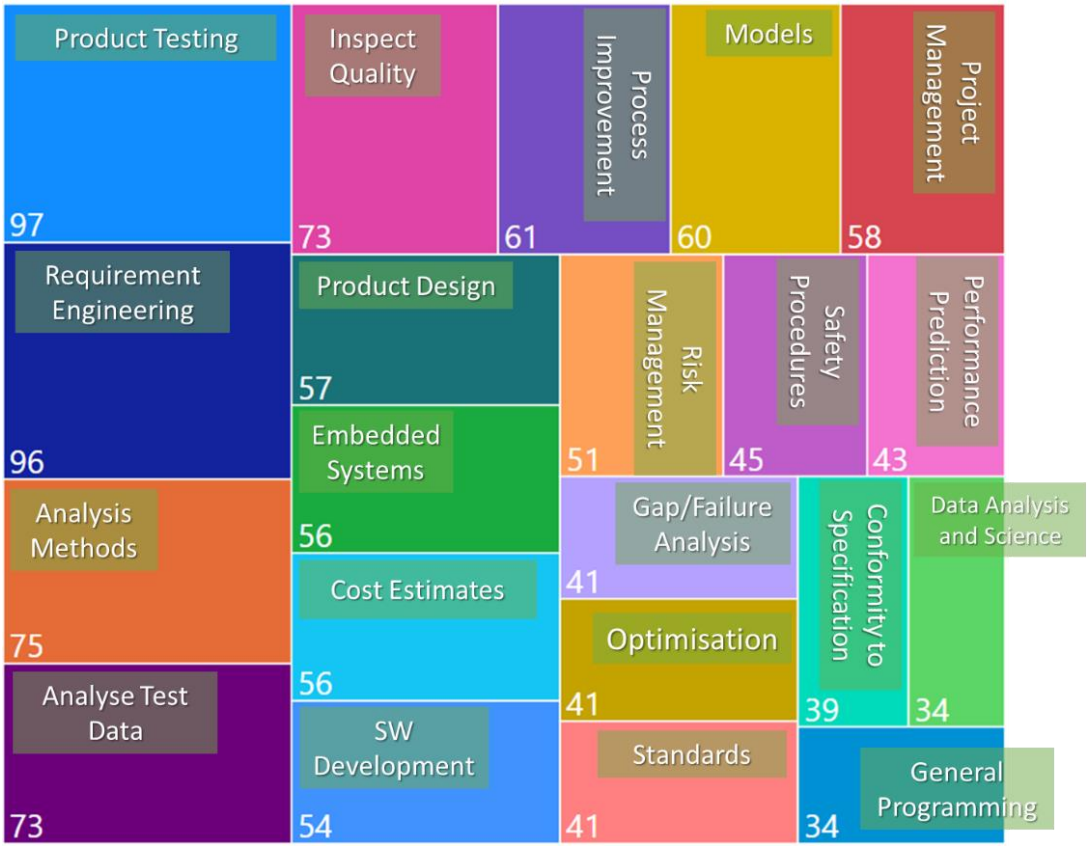

Figure 35: Cross-sectoral Competence

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Figure 36: Job roles relevant to the vehicle to grid concept

3.2.2 Recommendations and Actions

- Battery and grid-relevant knowledge, together with IT skills, will need to be strengthened to develop and operate the future vehicle to grid concepts and business services.

3.2.3 Target Groups

Utilities companies/electric energy providers, grid operators, charging infrastructure providers, fleet operators.

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4 EV Testing, Certification, Type Approval, Roadworthiness Tests

This category contains activities and trends related to technical aspects of electric vehicles and charging infrastructure **before** they can be placed on the market and put into operation, as well as periodic **roadworthiness tests** of electric vehicles. Relevant technical expertise is closely linked to legislation, standards, and manuals.

In the following text, these sub-trends are discussed in more detail:

- Testing of Electric Vehicles
- Testing and Certification of Charging Infrastructure
- Type Approval of Electric Vehicles
- Periodic Roadworthiness Tests of Electric Vehicles

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4.1 TESTING OF ELECTRIC VEHICLES

To ensure safety and conformity, all existing and future EV vehicles must be tested for homologation at both the full-vehicle and component levels. Aside from the vehicles themselves, every other factor that affects operational safety must be tested as well.[31]

Therefore, it also covers the charging interfaces and the associated systems that enable EVs, charging stations, and back-office systems to communicate. Additionally, EV testing involves battery packs and the modules they are made of, containing battery cells. Therefore, battery cells and battery packs are both subjects to different testing requirements.

The process entails the conformance testing of all electrical components such as plugs, cables, connectors, wiring, and switches. EVs bring together the automotive industry (ISO standards) and the electrical industry (IEC standards) from a testing and certification perspective.

All of the above adds to the complexity of the process, bringing higher demands on testing facilities and the qualification of the workforce.

4.1.1 Skills Agenda

Sector-specific and cross-sectoral competencies relevant to this sub-trend are visualised below. Job roles that are composed of mapped skills are then shown in the word cloud.

[31] *Electric Car Testing*. (2020, May 14). DEKRA Product Testing & Certification. https://www.dekra-product-safety.com/en/electric-car-testing (accessed on 11/08/2021)

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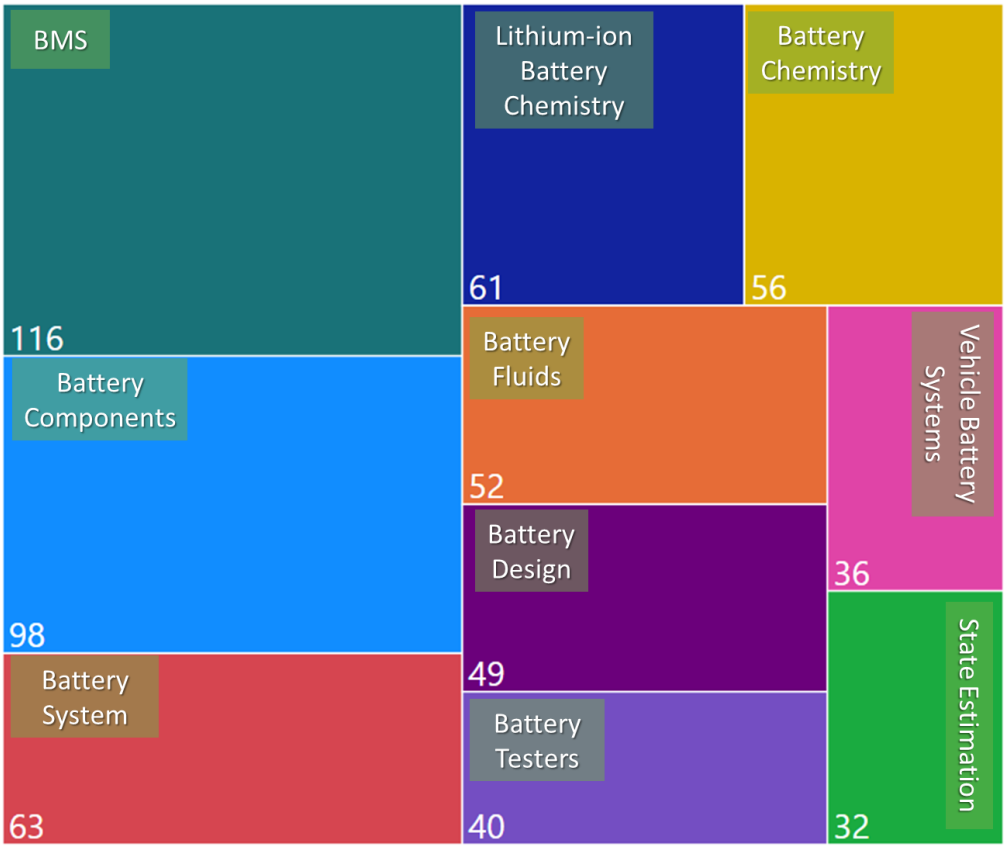

Figure 37: Sector Specific Competence

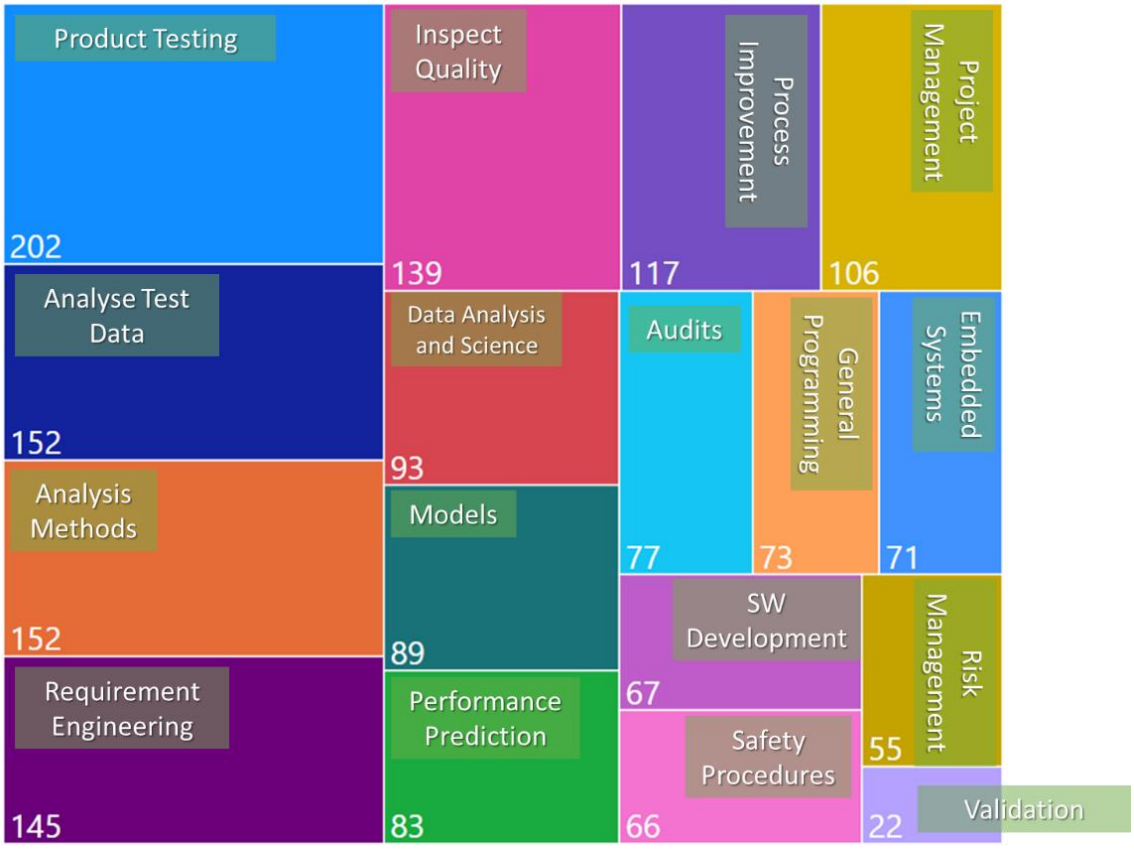

Figure 38: Cross-sectoral Competence

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Figure 39: Job roles relevant to testing of electric vehicles

4.1.2 Recommendations and Actions

- Given the systemic shift and increasing complexity of the process, as explained above, vehicle testing, certification, and inspection companies will need to invest in acquiring new technologies and systems. At the same time, employees of these companies will need to expand and improve their knowledge and skills, especially in electrical and high voltage fields.

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- One of the most critical activities is product testing. Concerning EVs, that means vehicle testing, EV battery testing, and EV charging interface and components testing. Therefore, inventing and creating testing procedures plays an essential role in the companies' competence.
- Scope for EVs testing comprises electrical safety testing, mechanical safety testing, performance testing, conformance, and interoperability testing, functional safety testing, electromagnetic compatibility testing, wireless testing, cybersecurity testing, software testing, environmental & stress testing, and chemical testing.
- EV battery-related services include functional safety, electrical safety, performance and durability testing, environmental testing, development testing, validation testing, homologation testing, and certification.
- EV charging interface, electronics & components services include electrical safety testing, interoperability, conformance testing, electromagnetic compatibility testing, functional safety testing, development testing, validation testing, environmental testing, and connected car services.
- Focus on safety aspects, BMS testing, and risk mitigation competence concerning product design is crucial.
- Assisting vehicle and components producers in product development optimization, for example, focusing on safety aspects, compliance with standards, or manufacturers employee's training, belong to very valuable services as well.[32,33]
- Together with technical and chemical expertise, knowledge of certification procedures, relevant legislation, and standards is a must.

4.1.3 Target Groups

Vehicle testing and certification companies, vehicle inspection companies, standardisation bodies, legislators.

[32] *E-MOBILITA - SLUŽBY PRO VOZIDLA*. (2020). TÜV SÜD. https://www.tuvsud.com/cs-cz/odvetvi/mobilita-a-automobilovy-prumysl/vyrobci-vozidel-oem/e-mobilita/e-mobilita-sluzby-pro-vozidla (accessed on 11/08/2021)

[33] TÜV SÜD. (2020). *E-mobility brochure*. https://www.tuvsud.com/cs-cz/-/media/global/pdf-files/brochures-and-infosheets/mobility-and-automotive/tuvsud-e-mobility_brochure.pdf (accessed on 11/08/2021)

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4.2 TESTING AND CERTIFICATION OF CHARGING INFRASTRUCTURE

End-to-end testing of EV charging infrastructure is essential to contribute to a flawless charging experience for EV drivers, with interoperability as the critical element. Manufacturers of charging infrastructure and connectors are developing equipment based on new technologies that require extensive testing and certification to relevant standards by an independent party.[33]

For example, charging requires working with high currents, which makes specific charging points and wall boxes requirements regarding safety, ease of use, and the service life.[34] Charging stations' testing and certification include electrical safety testing, electromagnetic compatibility testing, interoperability & conformance testing, or environmental testing.[35] In addition, all charging station components need to be designed to sustain different weather and climate conditions. Apart from AC/DC charging stations, global standards have also been developed for **wireless charging**.

When many electric vehicles need to be charged simultaneously, the **stability** of the power supply system becomes an important issue that must be checked. Such testing includes, for example, circuit feedback. Furthermore, it is vital to ensure that no power outages can occur due to overloading of the system.[36] In the future, the number of more complex projects, comprising a battery storage system and solar panels installed on the property of the charging stations, will increase, and so will the requirements on the qualifications and expertise needed.

Electric vehicles (EV) charging infrastructure is also as vulnerable to **cyber threats** as any other connected device. Therefore, security should primarily focus on communication, mobile apps, firmware updates, and physical access points. Specific evaluation and security verifications services, therefore, are increasingly important.[37]

[34] *DEKRA expert tip: electric vehicle charging stations.* (2021). Dekra. https://www.dekra.com/en/dekra-expert-tip-electric-vehicle-charging-stations/ (accessed on 11/08/2021)
[35] *EV Charging Station and Infrastructure Testing | DEKRA.* (2021). Dekra. https://www.dekra.com/en/ev-charging-station-and-infrastructure-testing/ (accessed on 11/08/2021)
[36] *E-MOBILITA - INFRASTRUKTURA.* (2021). TÜV SÜD. https://www.tuvsud.com/cs-cz/odvetvi/mobilita-a-automobilovy-prumysl/vyrobci-vozidel-oem/e-mobilita/e-mobilita-infrastruktura (accessed on 11/08/2021)
[37] *The importance of cybersecurity in electric vehicle charging stations*. (2021, June 21). DEKRA Product Testing & Certification. https://www.dekra-product-safety.com/en/importance-cybersecurity-electric-vehicle-charging-stations (accessed on 11/08/2021)

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4.2.1 Skills Agenda

Sector specific and cross-sectoral competences relevant to this sub-trend are visualised below.

Job roles that are composed of mapped skills are then shown in the word cloud.

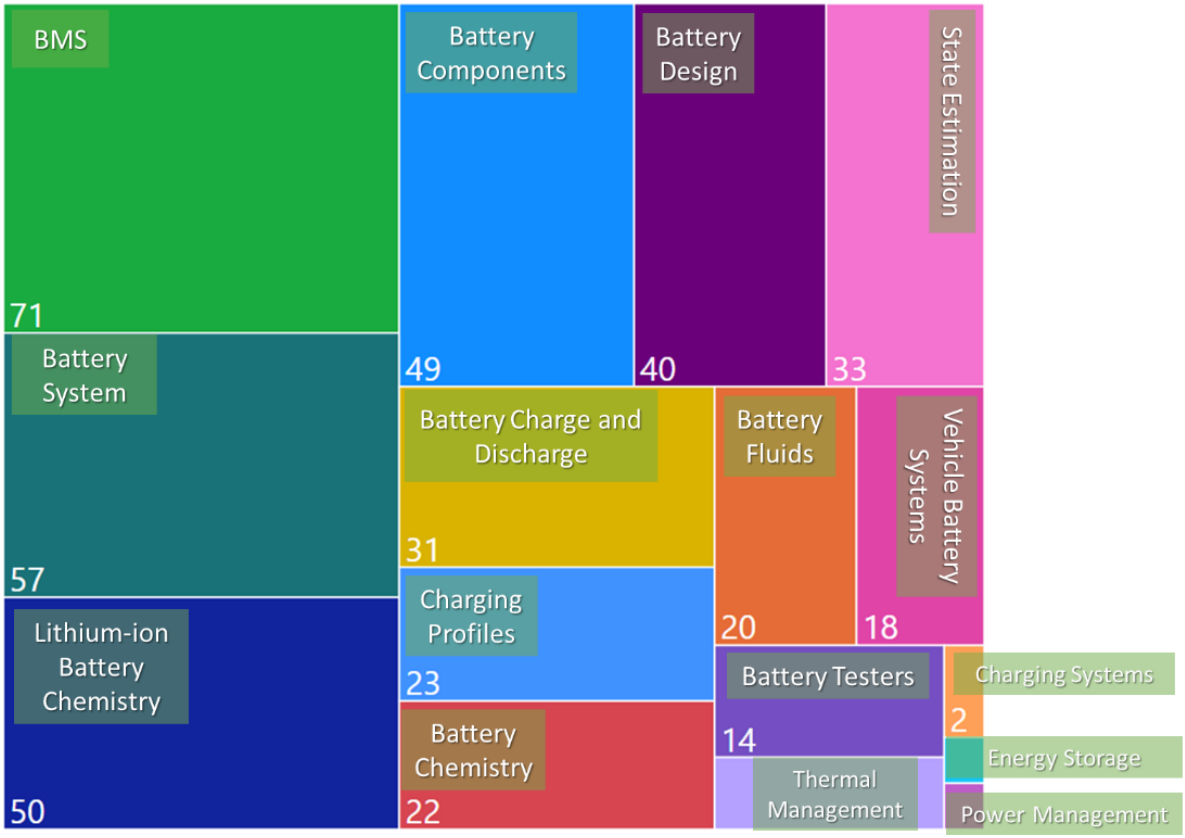

Figure 40: Sector Specific Competence

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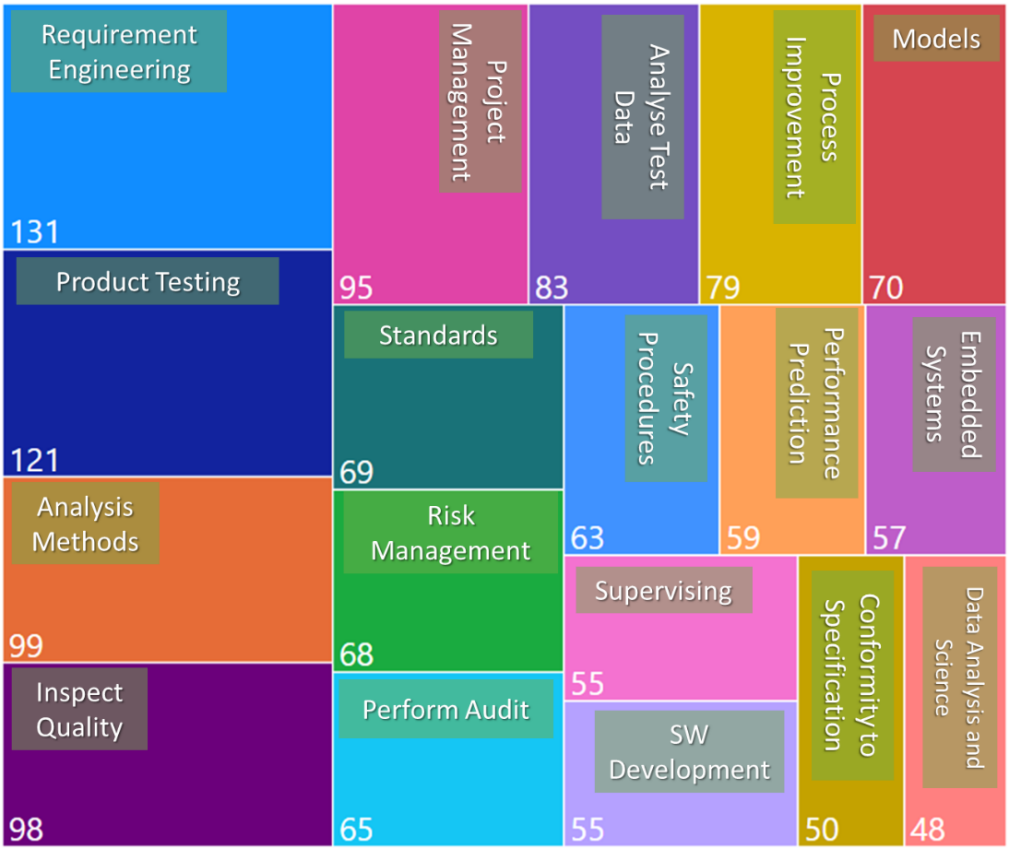

Figure 41: Cross-sectoral Competence

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Figure 42: Job roles relevant to testing and certification of charging infrastructure

4.2.2 Recommendations and Actions

- Expertise related to different devices – wall boxes, charging poles and stations, in-cable control protective devices, and wireless/inductive charging is needed.
- Digital communication and grid connection guidelines and standards must be followed as well.
- Different aspects of safety, primarily electrical, will be even more critical with the increased charging power of the stations.

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- Same as for vehicles - knowledge of testing procedures, standards, and legislation is crucial.
- The services of the certification and testing companies, and therefore the required competence of their employees, could be considerably broad. For example, apart from testing and certification of charging stations and their components, these could also include consultancy to charging points/stations producers (products, interoperability) and builders and operators (e.g. impact on the grid) or regular inspections of the sites.

4.2.4 Target Groups

Certification and testing companies, IT and SW companies, power grid operators, standardisation bodies, legislators.

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4.3 TYPE APPROVAL OF ELECTRIC VEHICLES

Type approval is the process applied by national authorities to certify that a vehicle model meets all EU safety, environmental, and conformity of production requirements before allowing it to be placed on the EU market.[38] Approval authorities are established or appointed by EU countries and notified to the European Commission. The majority of EU countries have a type approval authority on their territory.[39]

Core elements of a type approval process include 1. compliance of the vehicle manufacturer to all applicable technical requirements, 2. testing by certified technical service, 3. approval by the national approval authority, 4. conformity of production by the manufacturer in agreement with the approval authority, 5. certificate of conformity issued by the manufacturer to the end-user.[40]

The primary legal basis in the EU for passenger cars is Regulation (EU) 2018/858. As for international technical harmonization of vehicles, UNECE Regulations are of crucial importance. Specific requirements related to electric vehicles have been added or updated, e.g. electric safety, adequate protection against electric shock to all passengers and the driver, and energy storage (batteries protected against vibrations/shocks, short circuits, fire, and thermal influences, etc.).

EVs have a new and additional layer in the type approval process. In addition to all conventional component approvals relevant for homologation, all-electric installations need to fully comply with the specific technical regulations. In addition, functional safety becomes a very relevant issue as mechanical and electronic devices need to inter-operate.[41]

[38] *RSA.ie - Vehicle Type Approval*. (2021). RSA. https://www.rsa.ie/en/RSA/Your-Vehicle/Vehicle-Standards/Vehicle-Type-Approval-/ (accessed on 11/08/2021)
[39] *Technical harmonisation in the EU*. (2016, July 5). Internal Market, Industry, Entrepreneurship and SMEs - European Commission. https://ec.europa.eu/growth/sectors/automotive/technical-harmonisation/eu_en (accessed on 11/08/2021)
[40] *UNECE Adopts Type Approval for Electric and Hybrid Vehicles' Electric Safety Requirements; Applies in 41 Countries.* (2010). Green Car Congress. https://www.greencarcongress.com/2010/03/unece100-20100310.html (accessed on 11/08/2021)
[41] *e-Homologation.* (2021). Www.Tuv-Sud.Com.Tr. https://www.tuv-sud.com.tr/tr-en/industry/automotive-transportation/e-mobility/e-mobility-vehicle-services/e-homologation (accessed on 11/08/2021)

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4.1.4 Skills Agenda

Cross-sectoral competencies relevant to this sub-trend are visualised below (mapping for sector-specific competencies was not possible due to lack of data). Job roles that are composed of mapped skills are then shown in the word cloud.

Figure 43: Cross Sectoral Competence

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Figure 44: Job roles relevant to type approval of electric vehicles

4.3.2 Recommendations and Actions

- EV design also requires other specialised know-how and expertise (including standards and regulations) apart from all conventional component approvals as more electric installations, and interoperability aspects come into place. EV traction battery, for instance, needs specific approval/homologation (like compliance with UNECE Regulation 100)[42]. All the stakeholders in the type approval process need to reflect those and follow the pace of development.
- Technical services, for example, provide training for their employees in their competence centers to respond to those challenges,[43] which will need to be expanded in the future.

[42] *TRACTION BATTERY APPROVAL ACCORDING TO INTERNATIONAL STANDARDS*. (2021). TÜV SÜD. https://www.tuvsud.com/en/industries/mobility-and-automotive/automotive-and-oem/automotive-testing-solutions/battery-testing/traction-battery-approval-according-to-international-standards (accessed on 26/08/2021)

[43] *DEKRA expert tip: homologation of electric vehicles | DEKRA*. (2021). Dekra. https://www.dekra.com/en/expert-tip-homologation/ (accessed on 11/08/2021)

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- Technical services also need to work more intensively with other industry partners to create specifications and processes that comply with existing and emerging regulations.
- After conducting tests, technical services competence includes preparing the necessary technical reporting and often also assisting in handling the approval process with the authorities. Given the increase of complexity in the process, more employees will also be needed for these tasks.
- Type approval authorities and EU and national legislators need to continuously update their knowledge on new technologies and be in touch with industrial partners to appropriately respond to innovation development and safety challenges.

4.3.3 Target Groups

Type approval authorities, testing companies, technical services, EV manufacturers, legislators (national, EU, international), standardisation bodies.

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4.4 PERIODIC ROADWORTHINESS TESTS OF ELECTRIC VEHICLES

A properly maintained and fully functioning vehicle meeting all safety requirements is less likely to be involved in a road accident. Therefore, based on the EU legislation (Directive 2014/45/EU), passenger cars must undergo a regular roadworthiness test at least within the following intervals: four years after the date on which the vehicle was first registered, and after that, every two years.[44]

According to the discussion with experts, it seems periodic checks of electrified vehicles are currently within the same scope as in the case of vehicles with an internal combustion engine (apart from emission testing in the case of battery electric vehicles, of course).[45] However, some development in this area might be expected with further expansion of the EV market and used EV market.

4.4.2 Skills Agenda

In the future, relevant job roles that could include sector specific and cross-sectoral competencies are visualised below. Job roles themselves are then shown in the word cloud.

[44] *Vehicle inspection*. (2020, June 8). Mobility and Transport - European Commission. https://ec.europa.eu/transport/road_safety/topics/vehicles/inspection_en (accessed on 11/018/2021)
[45] *ALBATTS. D5.1 - Desk research and data analysis for sub-sector IMBA - Release* 1. (2020). Albatts. https://www.project-albatts.eu/Media/Publications/4/Publications_4_20200930_12811.pdf

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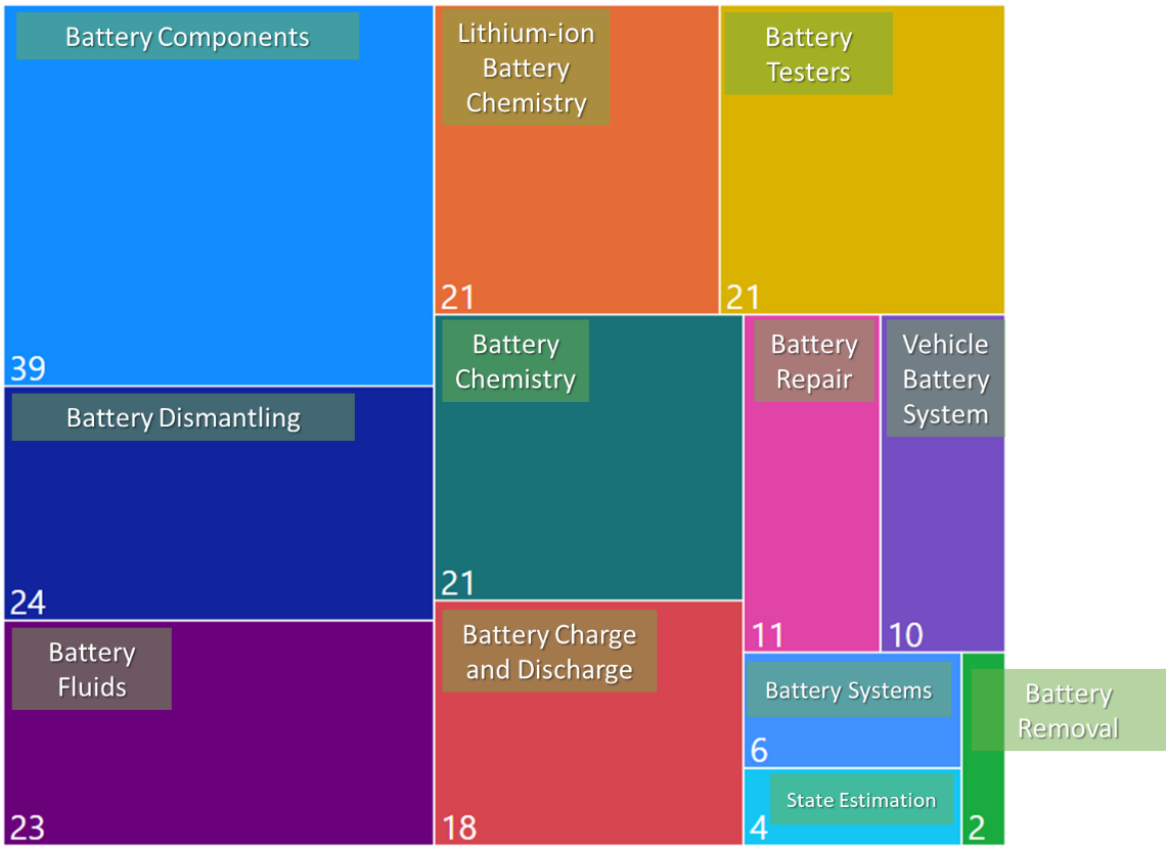

Figure 45: Sector Specific Competence

Figure 46: Cross-sectoral Competence

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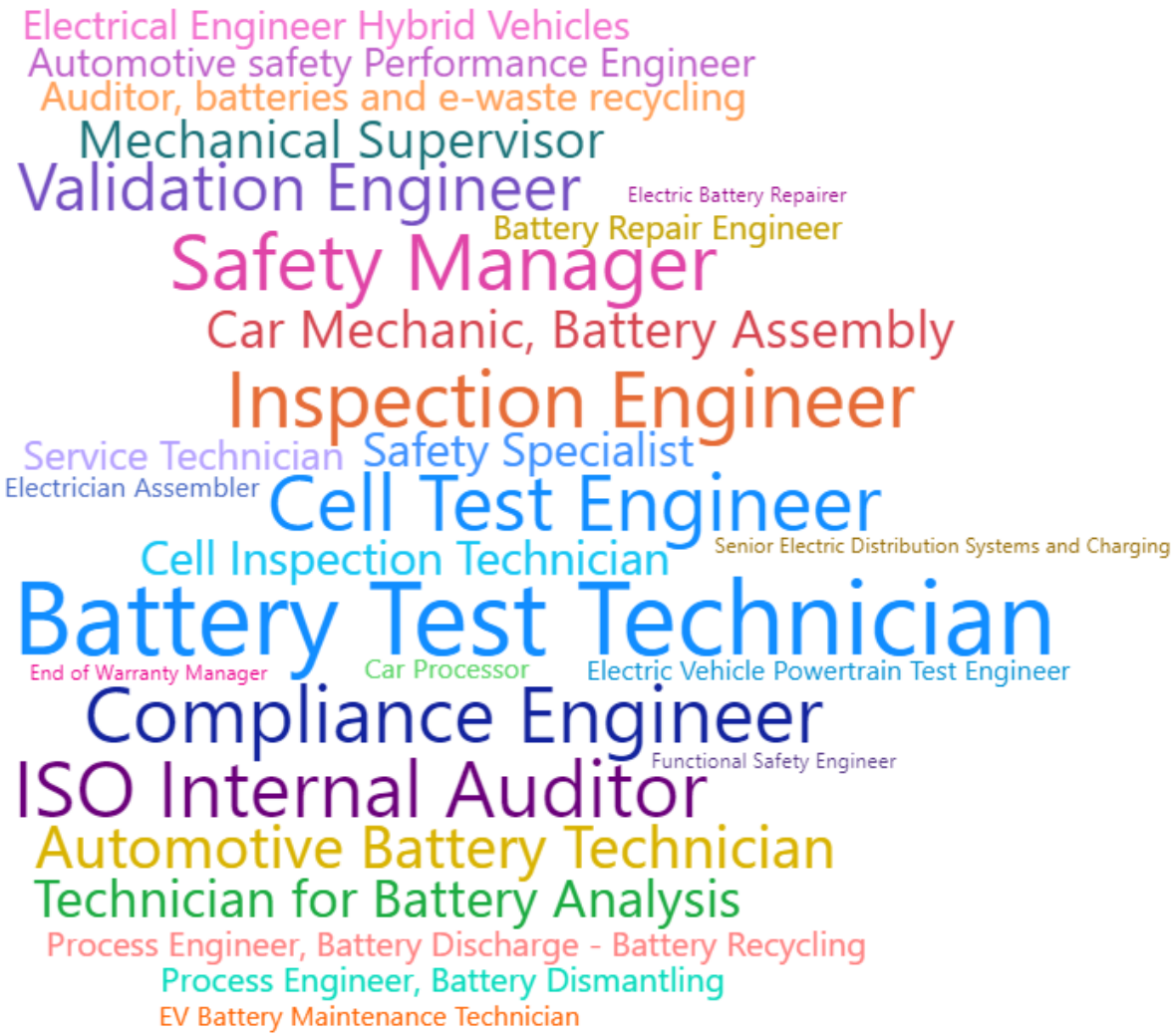

Figure 47: Job roles relevant to periodic roadworthiness tests of electric vehicles

4.4.2 Recommendations and Actions

- As indicated above, so far, specific education or professional qualification has not been needed. However, with the increased number of EVs in operation and development of the used cars market, a need for some specific steps could be assessed (also considering fire safety related to, e.g. possibly damaged battery).
- If the voltage system and battery had to be checked, then similar requirements would be required such as those for repair shops´ personnel.
- Processes, equipment, and proper guidelines should be strengthened and updated to allow EV components checks.

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4.4.3 Target Groups

Roadworthiness testing centers, EU and national legislators (usually Ministry of Transport), used car dealers.

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5 Electrification of Vessels

The electrification of vessels is advancing rapidly, particularly in **Northern Europe** and **Norway,** with **shortsea** segments and **car** and **passenger ferries** at the forefront.

Over the next several years, a deeper understanding of how batteries work is needed for many groups of people involved in the maritime industry. In addition, **new battery technologies** will emerge and capture selected market segments increasing the diversity in battery installations.

Therefore, a specific focus on today's **Li-ion technology** will not be sufficient, as the operating principles of different types of batteries may vary significantly. An important driver for this is cost reduction. Thus, in the future, we expect that lower-cost technologies will become available.

We see that skillsets in programming, electronics, and electrochemistry **combined** will be crucial.

In the following text, these sub-trends are discussed in more detail:

- Servicing – Remote Diagnostics, Repair and Maintenance of Electric Vessels
- Autonomous Electrified Vessels
- Customer Product Design, Consulting, Fleet Management

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5.1 SERVICING - REMOTE DIAGNOSTICS, REPAIR, AND MAINTENANCE OF ELECTRIC VESSELS

Electronics & software are essential parts of a modern propulsion system, and a battery system is suitable for **remote diagnostics** and **over-the-air updates**. Furthermore, vessels travel across the oceans and can be more challenging to reach for service personnel than an electric road vehicle. Correspondingly the savings from remote diagnostics and repair can be much higher within the maritime segment compared to the automotive segment.

A key driver for this trend is the falling cost and increased **data** connectivity, transfer, and storage capacity. Rapid development in **cloud** architecture is key to remote and efficient servicing of modern vessels.

Modern Energy Storage Solutions (batteries ++) are designed with integrated advanced **sensors** and software. These solutions are typical examples of the Industrial Internet of Things (**IIoT**) and enablers for remote maritime battery installations servicing.

5.1.1 Skills Agenda

Sector-specific and cross-sectoral competencies relevant to this sub-trend are visualised below. Job roles that are composed of mapped skills are then shown in the word cloud.

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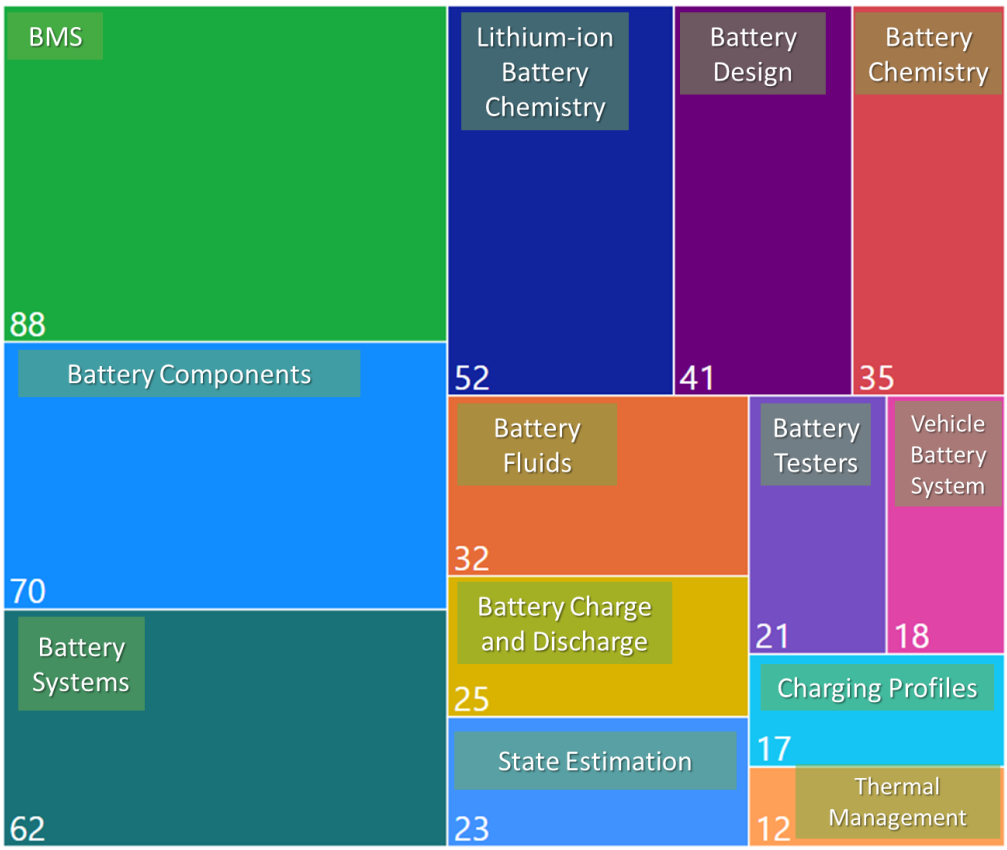

Figure 48: Sector Specific Competence

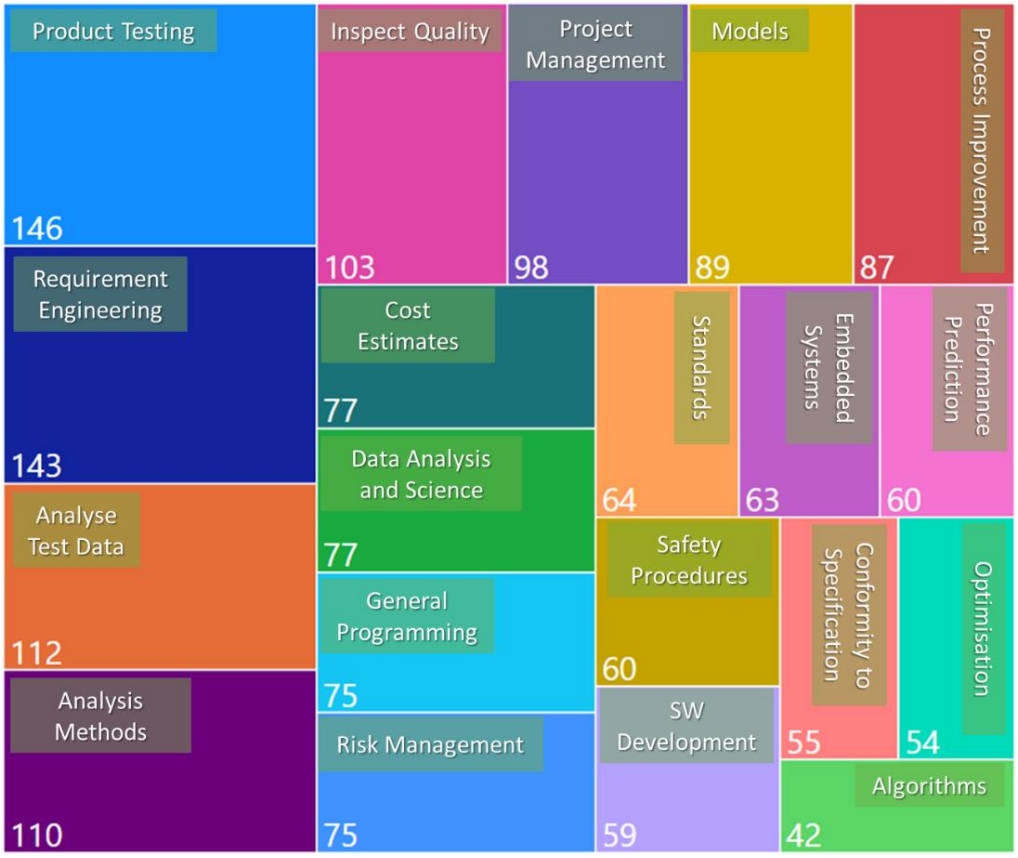

Figure 49: Cross-sectorall Competence

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Figure 50: Job roles related to servicing of electric vessels

5.1.2 Recommendations and Actions

Strengthening the **skills and training** in the following areas can be recommended:

- Electrochemistry & batteries
- Digital technology - remote diagnostics & fault finding
  - Robust programming enabling such techniques
  - Auto-diagnostics routines and corresponding reporting functions

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- Battery core knowledge, including basic electrochemistry

- Digital technology - Over the air update
  - Cyber security
  - Robust data transfer with fall-back solutions for intermittent connection failures
  - Data compression techniques for satellite data transfer
  - Communication protocols
  - Software engineering and development
- Competence within the data-driven approach to the problem solution, cloud-based technologies, and software development
- Electronics engineering
- Electrical engineering and fusing
- Mechanical engineering
- High voltage

5.1.3 Target Groups

Vessel building, operating and maintenance companies, vessel battery integrators, ship owners and OEMs.

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5.2 AUTONOMOUS ELECTRIFIED VESSELS

Autonomous vessel technology is gaining ground and, compared to traditional fossil fuel-powered vessels, electrified vessels are better suited for autonomy for several reasons:

- Electrified vessels have a better possibility of redundant power supply and are better suited to avoid blackout
- Batteries are virtually maintenance-free
- Similarly, electrically powered motors have a lower maintenance need than fossil fuel-powered motors
- Software plays a more critical role in electrified vessels than in traditional vessels
- Controlling electric and electronic devices by software is at least in principle easier than controlling mechanical devices by software.

All of the factors listed above lowers the bar for autonomous operation where controlling the entire vessel via **software routines** is crucial. Furthermore, all signals relevant for **sensors** are in the electrical form, whereas for traditional fossil-fuelled vessels, both the electrical and mechanical signals are involved.

5.2.1 Skills Agenda

Sector-specific and cross-sectoral competencies relevant to this sub-trend are visualised below. Job roles that are composed of mapped skills are then shown in the word cloud.

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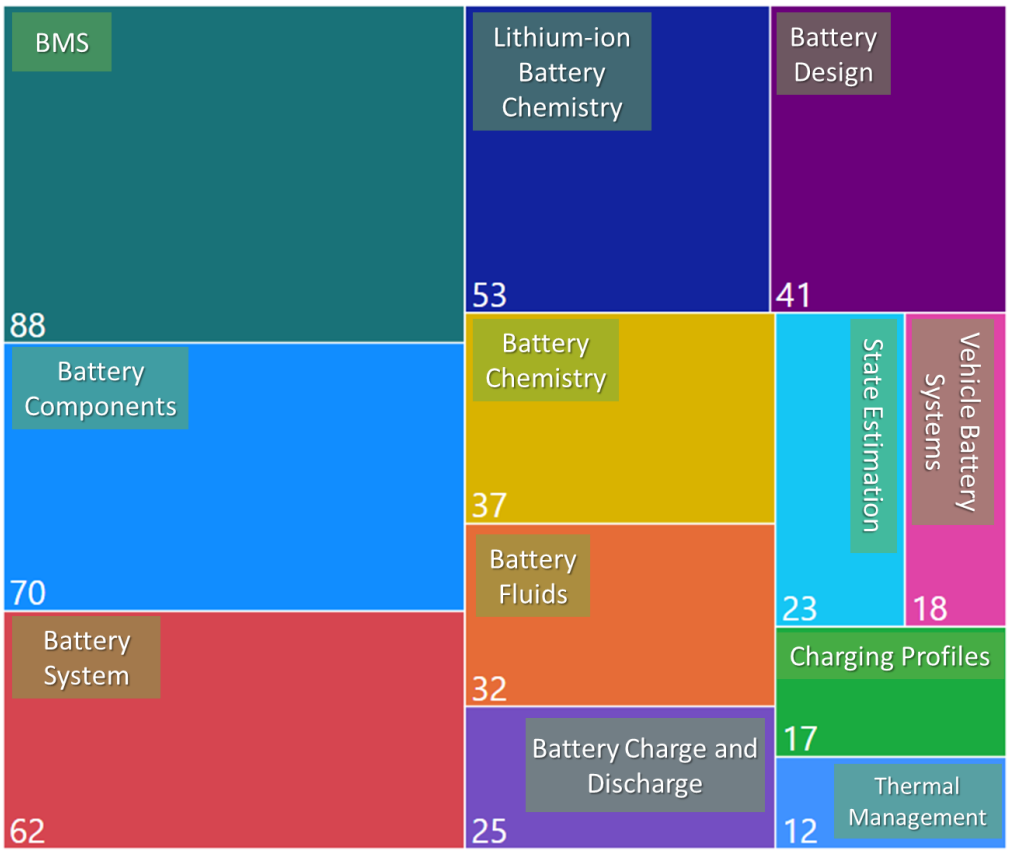

Figure 51: Sector Specific Competences

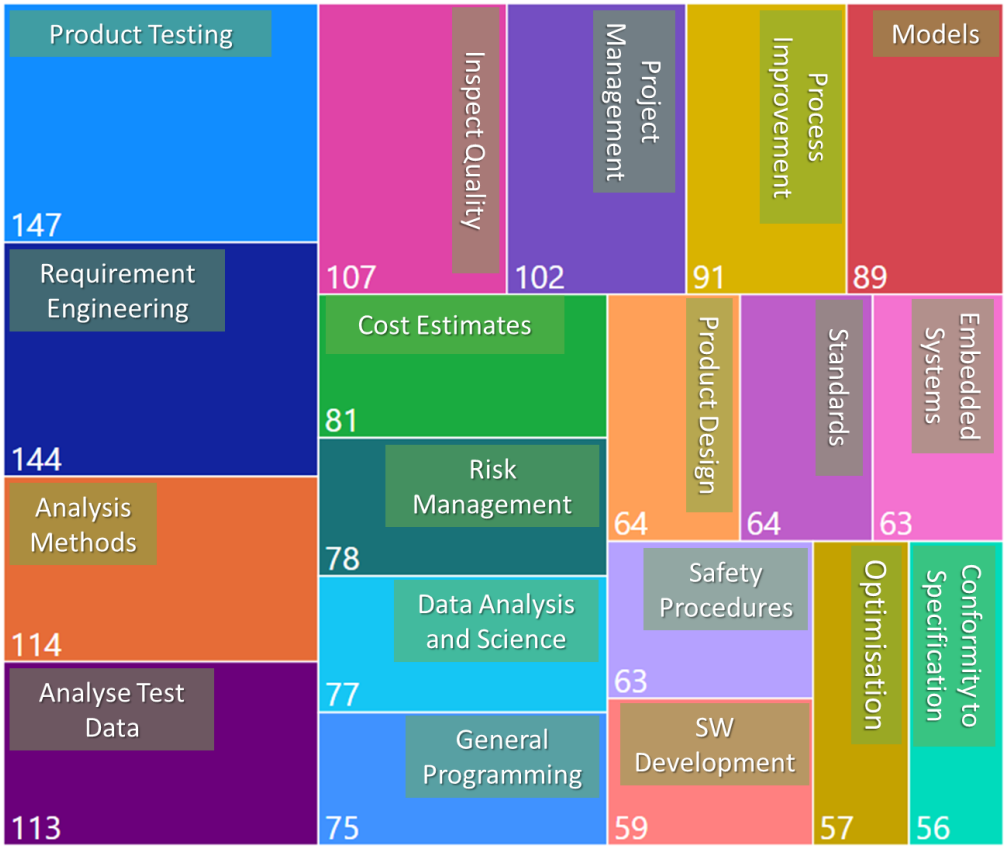

Figure 52: Cross-sectoral Competences

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Figure 53: Job roles relevant to autonomous electrified vessels

5.2.2 Recommendations and Actions

- Strengthening the skills and training people in **digital technology -** data scientists, test engineers, software developers, cloud solutions experts and cybersecurity experts and engineers - is necessary
  - Robust integration of many different systems into software **algorithms** for autonomous operation - focus in the educational system on creating redundancy for propulsion and manoeuvring systems resulting in fault-tolerant and robust solutions.

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5.2.3 Target Groups

Vessel building, operating and maintenance companies, vessel battery integrators, companies developing and integrating sensors, SW companies.

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5.3 CUSTOMER PRODUCT DESIGN, CONSULTING, FLEET MANAGEMENT

As electrification becomes more widespread, hybrid, plug-in hybrid, and dual fuel solutions become more common. Combining these solutions requires detailed knowledge on how the best features of each of the different systems can be used to make an **optimal system** solution.

The traditional **hybrid application** aims to optimize the operation of the internal combustion engine by using the battery to help handle energy peaks. However, for some systems, redesigning the internal combustion engine to be less capable of handling changes in output requirements while increasing the fuel efficiency can be attractive.

Designing and operating hybrid and dual fuel systems require skills both in internal combustion engines and batteries. Further, being able to make robust software routines to optimize the operation is crucial. Furthermore, simulation skills are also necessary to verify that the operation is optimized. Here, **AI** and **machine learning,** in addition to detailed battery knowledge and internal combustion engine knowledge, may be required.

For instance, batteries have increased impedance and decreased capacity over their lifetime. This will influence the **optimal setting** for a hybrid operation. Similarly, the battery temperature influences the internal impedance of the battery system, which again influences the optimal setting for hybrid operations.

5.3.1 Skills Agenda

Sector-specific and cross-sectoral competencies relevant to this sub-trend are visualised below. Job roles that are composed of mapped skills are then shown in the word cloud.

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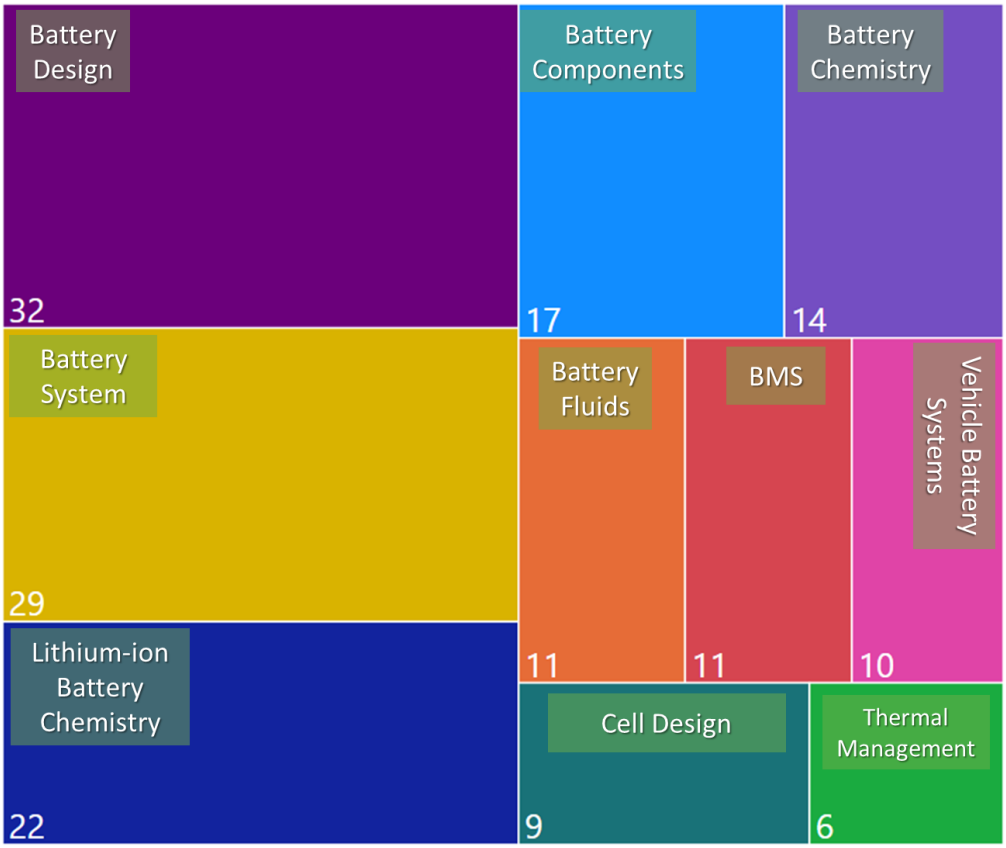

Figure 54: Sector Specific Competence

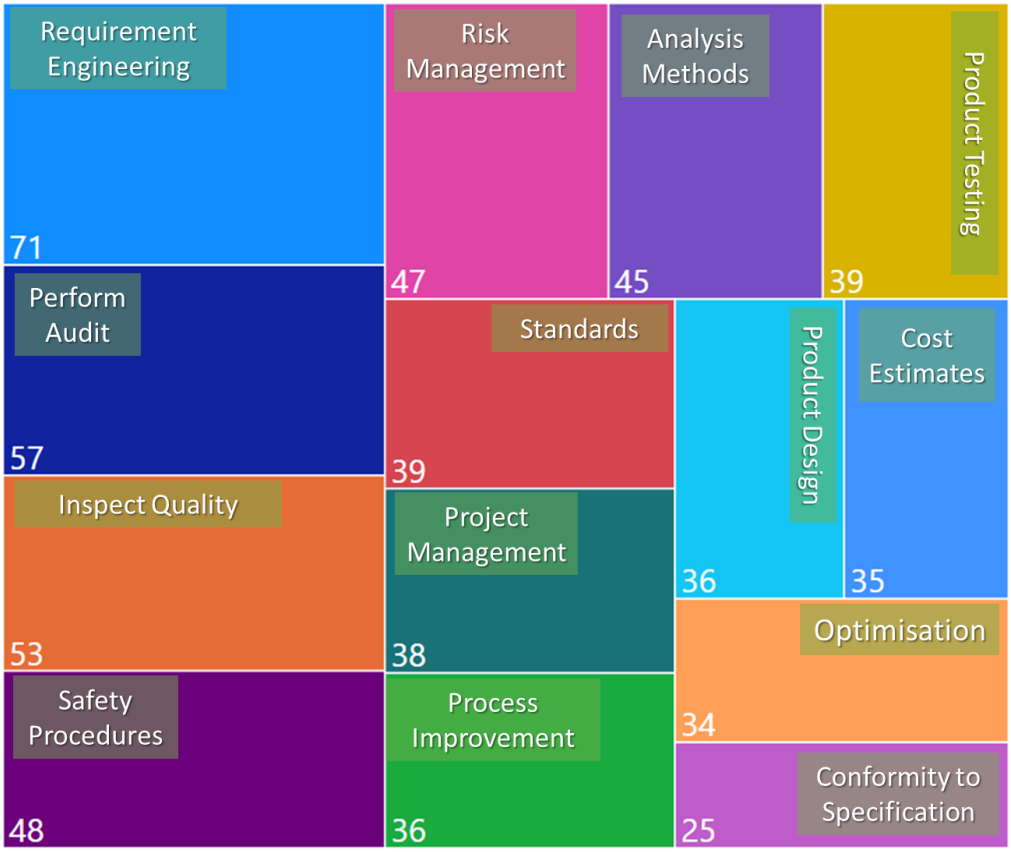

Figure 55: Cross-sectoral Competences

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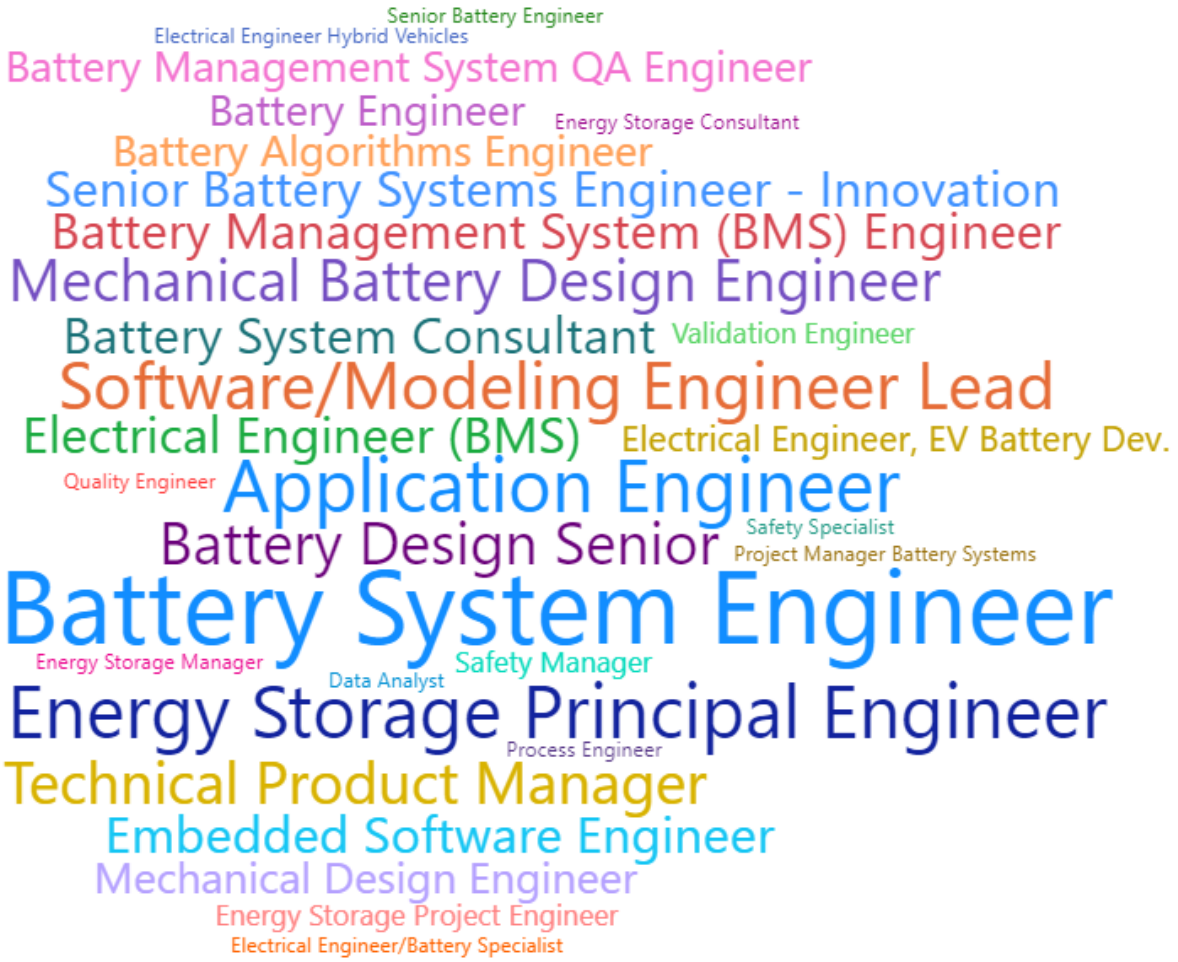

Figure 56: Job roles relevant to customer product design, consulting, fleet management

5.3.2 Recommendations and Actions

- To summarise, combining skills of **internal combustion engines, batteries** and **programming** is crucial, and the same person will likely need good skillsets for all three areas to ensure optimal operation.
- **Research and development** within the battery applications in vessels should be strengthened, mainly in areas of:
  - Safety
  - Cost-effectiveness
  - Robustness
  - The integration process of batteries into the vessels
- Knowledge on **safety requirements** for maritime should be strengthened:
  - Thermal management
  - Off gas handling
  - System-level safety

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- Risk evaluation
- SoC window limitation

5.3.3 Target Groups

Vessel building, operating and maintenance companies, battery system integrators, ship owners.

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