albatts

Alliance for Batteries Technology, Training and Skills

2019-2023

Battery job roles, skills, and competencies, ALBATTS Work Package 4 Research of 2022

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D4.8 Sectoral Intelligence definition for sub-sector ISIBA - Release 2

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List of Abbreviations

AC	…	Alternating Current
AD	…	Active Directory
AI	…	Artificial Intelligence
AQP	…	Advanced Quality Process
ATF	…	Authorised Treatment Facility
BES	…	Battery Energy Storage
BESS	…	Battery Energy Storage System
BEV	…	Battery Electric Vehicle
BMS	…	Battery Management System
BOP	…	Balance Of Plants
BTMS	…	Battery Thermal Management System
CAPA	…	Corrective Action and Preventive Action
CAPEX	…	CAPital EXPansion
CHE	…	Cargo handling equipment
CHE	…	Cargo-Handling Equipment
CO2	…	Carbon dioxide
COPQ	…	Cost of Poor Quality
DC	…	Direct Current
E&E	…	Electrical and electronic
ELV	…	End Of Life Vehicles
EMC	…	Electromagnetic Compatibility
EMS	…	Energy Management System
EPC	…	Engineering, Procurement, and Construction
ESS	…	Energy Storage Systems
ETAP	…	Electrical Transient and Analysis Program
EU	…	European Union
EV	…	Electric Vehicle
FAT	…	Factory Acceptance Testing
GUI	…	Graphical User Interface
GW	…	Giga Watt
HMI	…	Human-Machine Interface
HV	…	High Voltage
HVAC	…	Heating, Ventilation and Air Conditioning
HW	…	Hardware
ID	…	Identification
IP	…	Intellectual Property
ISO	…	the International Organization for Standardisation
ISS	…	Industrial Storage System
JHA	…	Job Hazard Analysis
LiB	…	Lithium-ion Batteries
Li-ion	…	Lithium-ion
LOTO	…	Lockout Tagout
LTO	…	lithium-titanium-oxide
LV	…	Low Voltage

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MBA	…	Master of Business Administration
MSc	…	Master of Science
Mt	…	Megaton
MV	…	Medium Voltage
MW	…	Mega Watt
NPD	…	New Product Development
O&M	…	Operation and Maintenance
OEM	…	Original Equipment Manufacturer
PCS	…	Power Conversion System
PhD	…	Doctor of philosophy (Philosophie Doctor)
PLM	…	Product Lifecycle Management
PV	…	Photovoltaic
QR	…	Quick Response code
R&D	…	Research and Development
RA	…	Risk Assessment
RES	…	Renewable Energy Sources
RFI	…	Requests for Information
RFP	…	Review Requests for Proposals
ROI	…	Return on Investment
RSS	…	Residential Storage System
SAT	…	Site Acceptance Testing
SCADA	…	Supervisory Control and Data Acquisition
SCAR	…	Supplier Corrective Actions
SLD	…	Single line diagram
SME	…	Small and Medium-sized Enterprise
SoC	…	State of Charge
SoH	…	State of Health
SPC	…	Statistical Process Control
SQC	…	Supplier Quality Scorecard
SW	…	Software
TCO	…	Total cost of ownership
TWh	…	Tera Watt-hour 10^{12}
UPS	…	Uninterruptible Power Supply
USD	…	United States Dollar
UVV	…	Unfallverhütungsvorschrift (regulation for accident prevention)
VET	…	Vocational Education and Training
VR	…	Virtual Reality
VRE	…	Variable Renewable Energy
WP	…	Work Package

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Executive Summary

In this deliverable, we cover the information yielded by the research and work conducted by Work Package 4 during the past year. We cover the following deliverables:

- Skills and Job Roles in Battery Applications Supporting the Modern Society - D4.7 Desk research and data analysis for sub-sector ISIBA- Release 3
- ALBATTS Workshops: Stationary Battery Applications, Job Roles & Skills - D4.4 Future Needs Definition for sub-sector ISIBA - Release 2

Skills and Job Roles in Battery Applications Supporting the Modern Society

This chapter summarizes and analyses the information yielded about the use of batteries and related job roles and skills by the 3rd release of the WP4 desk research. The following topics are covered: Data Centres, Renewable Power Farms, Heavy Work Machines and BESS in Residential Applications.

Data centres are not only an important part of the Internet infrastructure that enables today's information society, but they are also significant producers of CO_2 emissions. Batteries provide a green alternative to traditional diesel generators as backup systems. This section studies the job roles, skills, and knowledge needed with batteries in a data centre environment.

Battery energy storage systems are needed in **Renewable Power Farms** due to the intermittent nature of these power plants. In this section, we list battery-related job roles in data centres. We also provide information on the skills and knowledge needed by the staff whose job descriptions involve working with batteries. We cover wind, solar and hydroelectric power plants.

The **Heavy Work Machines** section studies the battery-related job roles, skills and knowledge required in the electrification process of heavy work machines. We cover mining equipment, forest machines, cargo Handling and heavy construction equipment. While these systems have a major role in construction of our infrastructure, technology, and the daily-used products, they are also contributors to the global CO2 emission. Thus, they form an important area for electrification.

In the **BESS in Residential Applications** section, we study the job roles, skills and knowledge required in the context of the domestic applications of Battery Energy Storage Systems. Residential Battery Energy Storage Systems (BESS) are battery systems that are installed and store electricity locally for home use.

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Building a Gigafactory interview

Here we study the job roles, skills and knowledge information provided by an interview with Mrs Katarina Borstedt, Director of Growth at Northvolt. The interview focused on the challenges of building a Gigafactory from the human resources point of view.

The Impact of The Battery Passport on The Battery Value Chain interview

The Battery Passport will provide European consumers and industry access to battery-related data. We interviewed Ms Claudia Gamon, a Member of the European Parliament, to gain further information about the system. In this chapter, we study the job role, skill, and knowledge needs emerging due to the eventual introduction of the Battery Passport.

Battery Energy Storage Enabling Sustainable Islands interview

This chapter provides skills and knowledge information from the interview with Mr Duarte Conde Silva, a Plant Manager at Graciólica (Graciosa Island, Azores). The island pursues a hybrid approach to island grid energy generation, combining wind, solar, and energy storage using lithium-ion batteries and thermal generation.

Recycling Electric Vehicles' Batteries webinar

Finally, we study the skills, knowledge and job roles identified when conducting the "Recycling EV Batteries: Skills and Qualifications Needed in Auto Workshops" webinar. It covered employee training.

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Introduction and Methodology

The methodological approach partaken to develop this report can be explained in accordance with the report structure – this follows yearly reporting on the selected battery applications or state-of-the-art domains. Various trends, technologies, stakeholders, and skills/job roles are described and analysed via desk research and workshops/interviews.

This report contains a comprehensive compact summary with the most important findings for further analysis and elaboration in WP3 – Sectoral Intelligence. That is where the final Sectoral Skills Intelligence and Strategy is being developed (release 2 for the year 2022) for the whole sector concerning inputs from WP4 and WP5 (stationary and mobile applications of batteries). Both of these inputs will be compared, and conclusions will be drawn. In addition, data from the previous year will be updated where possible.

The following information is summarised and will be provided as input to the WP3 in this report:

- **State-of-the-art on the battery applications**[1] researched by WP4 during 2022: 1) Data Centres; 2) Renewable Power Farms; 3) Heavy Work Machines; 4) BESS In Residential Applications.
    - The Renewable Power Farms chapter covered **wind, solar and hydropower**. It also visited the other energy sources, including geothermal, biomass and wave/tidal power plants.
    - The Heavy Work Machines[1] chapter covered **mining equipment, forest machines, cargo handling and heavy construction equipment**.
- Analysis of the **currently needed job profiles by industry** (selected stakeholders and companies relevant for the mobile applications as stated above and their job advertisements), analysis considers the following point of view: 1) design and development; 2) maintenance; 3) technical management and services.

[1]While **WP4** focuses primarily on **stationary battery applications**, we considered that **heavy work machines**, with their potential electrification, are too important to be left unstudied. The other factor is that we see heavy work machines as being close to the borderline area between stationary and mobile applications by for example being off-road systems.

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- Information on **future needs and other relevant data gathered via the organisation of workshops** and **interviews** during this year up to this point, namely: 1) building a gigafactory; 2) battery passport and battery value chain; 3) BESS and sustainability applications; and 4) recycling of EVs.

This report serves as a state-of-the-art overview and contains recommendations on re-/up-skilling and specific skills needs within analysed domains and topics. Needed job profiles are analysed as well.

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1 Skills and Job Roles in Battery Applications Supporting the Modern Society

1.1 DESK RESEARCH REPORT

1.1.1 Data centres

Data centres offer infrastructure for data processing and communications and utilities such as electricity, network security access, and uninterruptible power supplies (UPS), including racks, cabinets, cables, batteries, backup generators and data backup and recovery systems. Data centres consume around 1 % of the electricity used worldwide (appr. 205 TWh in 2018). The emissions can be comparable to the global aviation industry, with 900 billion kg of CO_2 annually. Reduction of CO_2 emissions is achievable by introducing cleaner technology by replacing diesel generators with batteries as power backup systems and applying renewable energy sources[2]. The battery-equipped data centres storing energy generated by VRE sources could also become important components in carbon-free energy systems.[3]

Batteries and UPS systems safeguard the functionality of data centres in outage situations. Many job roles emphasise essential infrastructure expertise that includes UPS/batteries. UPS and battery backup are frequently confused. The term UPS refers to a more sophisticated form of battery backup. All UPS are battery backups with improved protection levels. The main UPS topologies are Standby, Line-interactive, and On-line UPS systems. The technologies include Lead-acid and Lithium-ion systems, further described in WP4 desk research 3.

1.1.2 Renewable Power Farms

Renewable energy sources include solar, wind and water energy or hydropower, in which kinetic energy moves turbines connected to electricity generators. Electricity production from renewable sources is advantageous since they are “infinite”, generate little or zero emissions, and perfectly integrate into natural cycles.

Wind power plants

[2] https://energyinnovation.org/2020/03/17/how-much-energy-do-data-centers-really-use/, last accessed on 23.8.2022

[3] https://techwireasia.com/2021/04/the-data-centers-of-the-future-will-run-on-batteries/, last accessed on 23.8.2022

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A wind turbine is a system that converts the wind's kinetic energy into mechanical energy. Two types of wind farms exist based on where they are installed, on land or sea. The first is called onshore and is mainly designed and installed on open ground, hills, and mountains. The second, called offshore, is placed on the sea near coastal areas or farther with wind turbines mounted on a floating platform.

Solar power plants

Two types of solar power stations are photovoltaic and thermodynamic/concentrated.

Photovoltaic plants use the photovoltaic effect to produce electricity, i.e., the ability of certain semiconductor materials to generate electricity when exposed to light rays. Photovoltaic power stations have electrically interconnected photovoltaic modules that make up strings, which are connected in parallel and to an inverter to supply electric current. Solar radiation is captured by the solar panels in a power station's photovoltaic array. The inverter transforms the continuous current produced by the solar panels into an alternating current and converted by a transformer into a medium voltage current.

Thermodynamic solar plants (concentrated solar power stations) use mirrors to concentrate the sun's rays in a precise point called a receiver, which contains a heat-carrying liquid that stores and transports the sun's heat. The heat transforms the receiver liquid into steam, channelled through a piping system to power a turbine. The mechanical energy produced by the turbine is then transmitted to an alternator that transforms it into electricity.

Hydroelectric power plants

A hydroelectric power station transforms hydraulic energy from a natural or artificial watercourse into electricity. The water sets the turbines in motion, generating mechanical energy, and flows out of them into a discharge channel, through which it is returned to the watercourse. Directly connected to the turbine is the rotating electric generator (alternator), which transforms the mechanical energy received from the turbine into electrical power.

1.1.3 Heavy Work Machines

Heavy work machines discussed in this report include those categories studied in the WP4 Desk Research 3: Mining equipment, Forest machines, Cargo Handling and Heavy construction equipment. These systems enable the construction of our infrastructure, the technology we

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have access to and the products we use daily. At the same time, they contribute to the CO2 emissions that endanger our planet's climate, thus making them an interesting target for electrification and batteries. For example, the mining industry contributes 2-3 % of global CO2 emissions[4]. As another example, construction-related machines generate approximately 400 Mt of CO2 annually (1.1% of the global CO2 emissions).[5]

The eventual electrification of heavy machines, off-road mobile machinery aims to eliminate their emissions. An increasing number of heavy machines, such as mining and cargo handling equipment, are becoming electrified. The number of companies offering these machines is rising, and the prices are decreasing. It is expected, however, that we will witness a more rapid shift to electrification beyond 2030.[6]

Mining equipment

The mining machinery includes systems that aid surface and underground mining activities. They include[7] surface mining machinery such as crawler excavators, crawler dozers, motor graders, rigid dump trucks, and articulated dump trucks. The underground mining machinery includes electric shovels, hydraulic excavators, wheeled loaders, mining dozers, mining trucks, and drills. Industry experts expect that the electrification of underground mining machinery will be more probable if compared to surface mining machinery. That includes trucks, mining dozers and hydraulic excavators etc.[8]

Forest machines

Foresters and loggers use various machines to cut and process trees. Forwarders and skidders move felled logs to a roadside landing. Harvesters are wheeled or tracked machines used to cut trees with a cutting head. These systems are used together with forwarders and self-

[4] https://www.prnewswire.com/news-releases/global-electric-mining-equipment-market-is-projected-to-reach-usd-11-7-billion-by-2030--growing-at-a-cagr-of-19-6-during-the-forecast-period---as-per-tersus-strategy-report-301481438.html, last accessed in June, 2022

[5] Electric Construction Machines Vital for Greener Construction, https://www.idtechex.com/en/research-article/electric-construction-machines-vital-for-greener-construction/26187, Last accessed in June 2022

[6] Key Factors Driving the Rise of Electric Equipment and Heavy Machinery, https://blog.marketresearch.com/the-future-of-electric-equipment-and-heavy-machinery, last accessed in June 2022

[7] https://www.marketsandmarkets.com/Market-Reports/mining-equipment-market-99264577.html, last accessed in June 2022

[8] https://www.marketsandmarkets.com/Market-Reports/mining-equipment-market-99264577.html, last accessed in June 2022

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loading trucks. Log loaders of various kinds are used to sort and stack logs into piles. Loaders move the logs onto transport trucks. In our desk research 3, we concluded that there are possibly not many fully electric forest machines, if any, in the market yet while prototypes have been presented. However, several machine manufacturers have already introduced electro-hybrid systems.

Cargo handling

Cargo handling equipment (CHE) has a significant role in port operations, distribution centres and heavy industry and the air quality in them. They have great importance to the economy. Cargo handling machines, especially at ports with a lot of activity, is an area where Li-ion batteries can be used to achieve the carbon-neutral demands in Europe[9].

The CHE sector includes various equipment types, such as yard tractors, electric forklifts, and cranes that move cargo in ports and freight terminals, as well as on and off marine vessels, railcars, and trucks[10]. The charging infrastructure with charging stations is important for supporting battery-operated machines and minimising peak power consumption[11].

Heavy construction equipment

Construction equipment is used in infrastructure or structural engineering-related operations. The equipment is used for excavation and digging of earth, compacting and levelling, transferring materials, placing materials and the actual construction processes.[12] Construction equipment includes wheel loaders, backhoes, excavators, trucks, cranes, and forklifts. The manufacturers are launching electric versions of construction machines to make construction operations more sustainable.[13][14]

[9] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en last accessed on 7.7.2022

[10] https://www.epa.gov/ports-initiative/cargo-handling-equipment-che-best-practices-improve-air-quality last accessed on 6.7.2022

[11] https://www.kalmarglobal.com/491467/globalassets/media/216119/216119_FastCharge-WP-2019-WEB.pdf, last accessed on 6.7.2022

[12] https://www.sciencedirect.com/topics/engineering/construction-equipment, last accessed on 11.8.2022

[13] https://www.bigrentz.com/blog/electric-construction-equipment, last accessed on 11.8.2022

[14] https://theconstructor.org/construction/heavy-construction-equipment-types/26305/, last accessed on 11.8.2022

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1.1.4 BESS in Residential Applications

Residential Battery Energy Storage Systems (BESS) are battery systems that are installed and store electricity locally for home use. It is more profitable when BESS is installed closer to an end-user[15], making a residential BESS an interesting solution to explore. Residential battery systems are used mainly to support the distributed generation model, combined with on-site generation from technologies such as photovoltaic (PV) and wind energy.

1.2 SKILLS AGENDA AND RECOMMENDATIONS

This section, on the one hand, summarises the skills and job role needs of the sectoral stakeholders and companies active in the aforementioned mobile applications. On the other hand, recommendations on concrete re-skilling and up-skilling requirements or other recommendations related to the skills agenda are provided and summarised.

1.1.1 Skills Agenda

Overall, 107 advertisements were analysed during the desk research from various companies specialising in 1) forest machines; 2) cargo handling; 3) heavy work machines; 4) data centres; 5) renewable power farms, and 6) construction machines.

Needs are categorised with the following structure:

- Design and Development
- Maintenance
- Technical Management and Services

Higher importance is given to the **sector-specific** and **transversal** technical skills/knowledge seen per individual category where applicable.

1.1.1.1 Design and Development

The most relevant job roles needed in the design and development engineering disciplines are:

- Electrical and electronics engineers
- Industrial engineers

[15] https://www.eurobat.org/images/news/publications/eurobat_batteryenergystorage_web.pdf Last accessed on 20.8.2021

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- Materials engineers
- Mechanical engineers
- Software developers or systems engineers
- Design and Development Engineers

Results of the job advertisements analysis and the desk research can be seen in **Figure 1** and **Figure 2**.

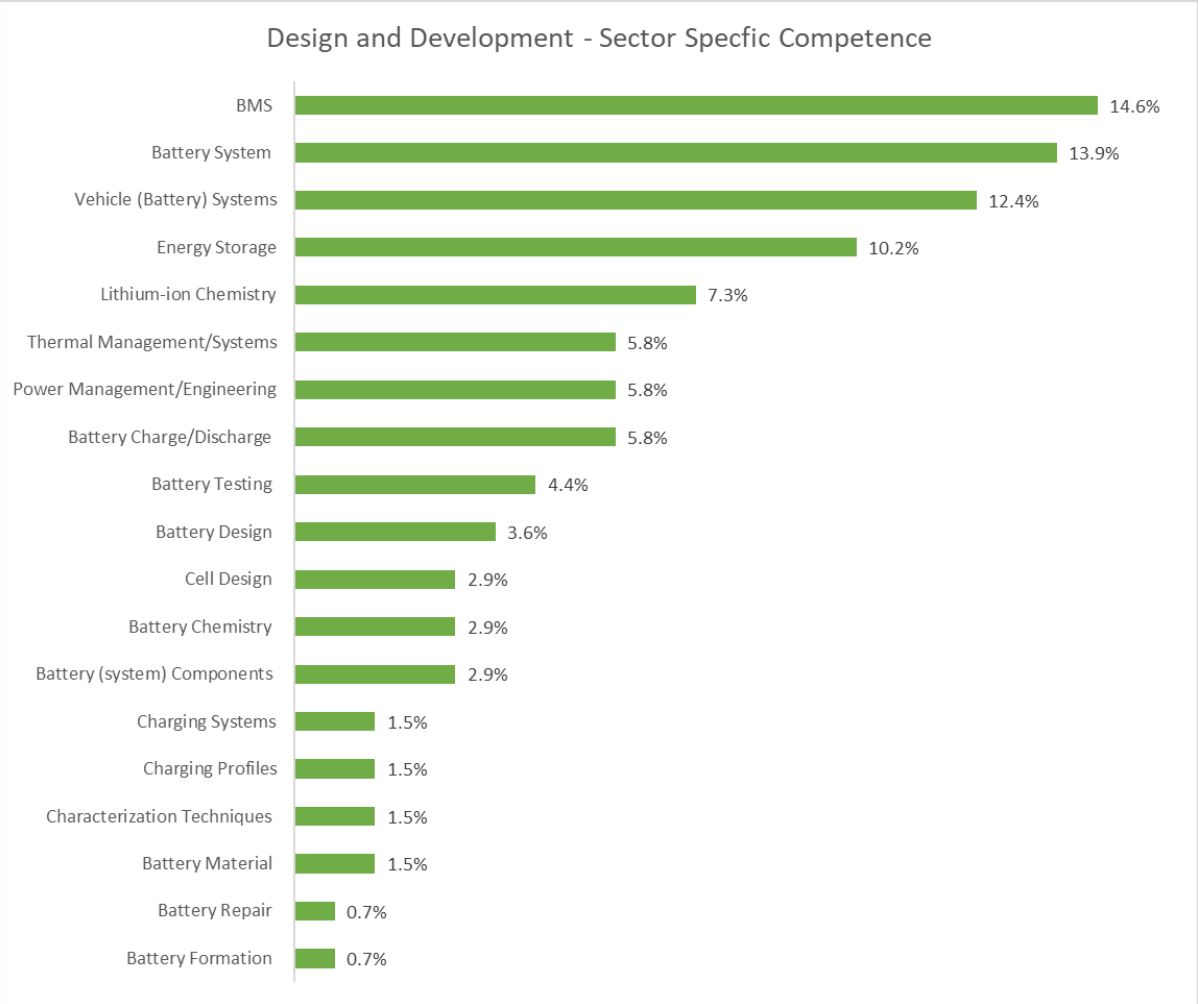

Figure 1: Design and Development – Sector-Specific Competence Needs

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Figure 2: Design and Development – Cross-Sectoral Specific Competence Needs

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1.1.1.2 Maintenance

The most relevant job roles needed in the maintenance disciplines are:

- Service technicians
- Field Service Technicians
- Maintenance Personnel
- Mechanics
- Electricians

Ordinary repair workers can do routine maintenance and repair, but the batteries, electrical systems and stationary battery systems often need a **specially trained** workforce.

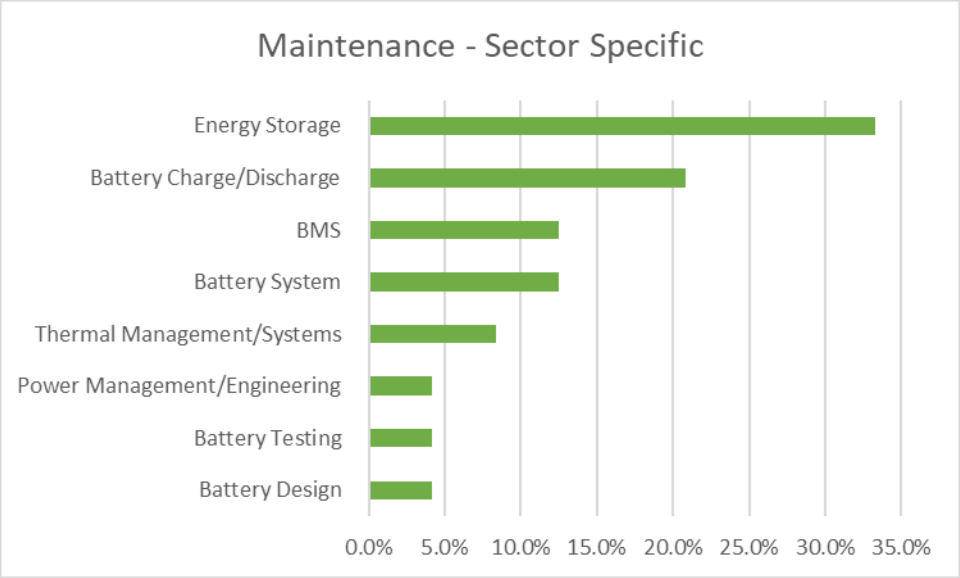

Figure 3: Maintenance – Sector-Specific Competence Needs

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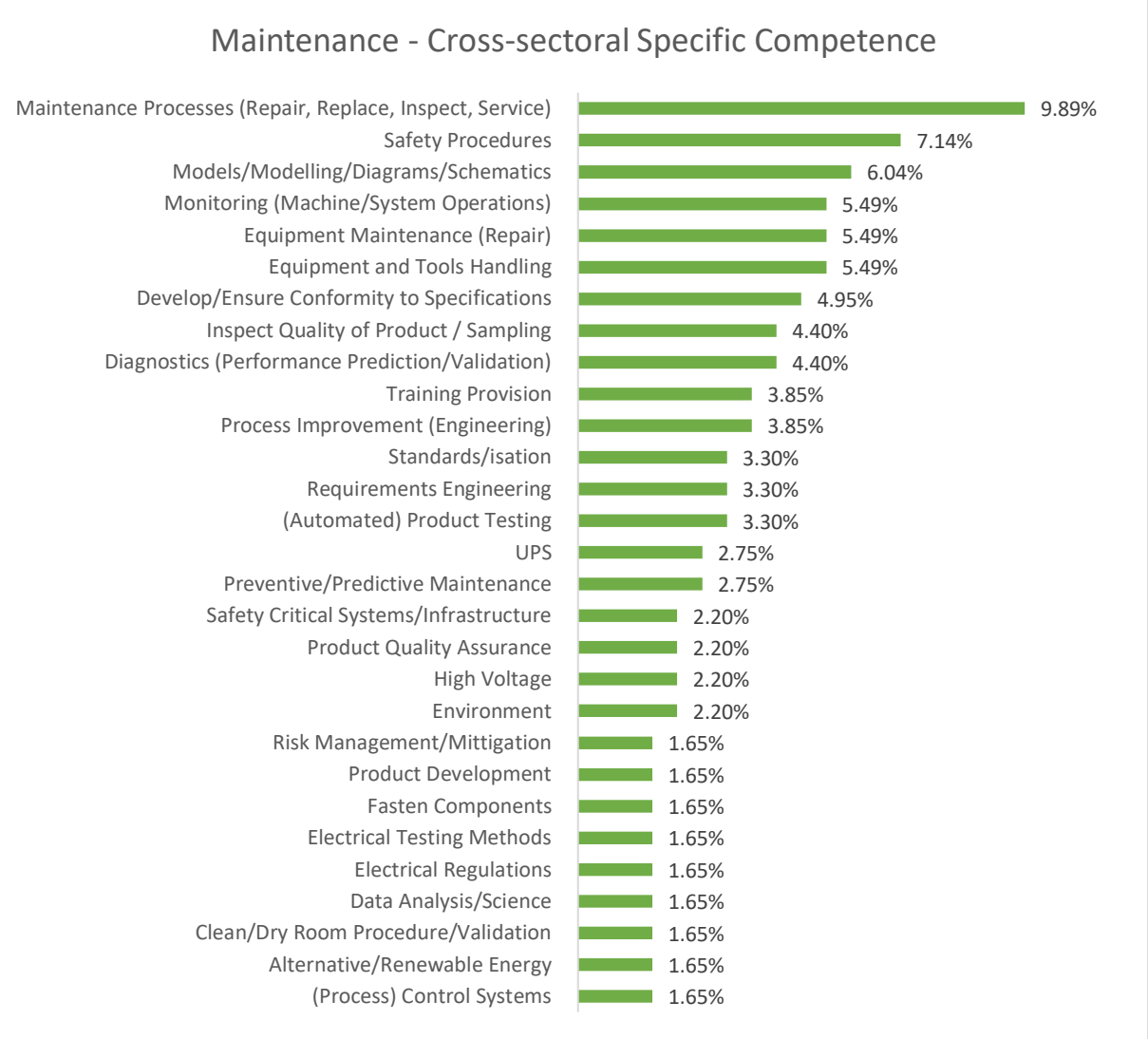

Figure 4: Maintenance – Cross Sectoral Specific Competence Needs

1.1.1.3 Technical Management and Services

The most relevant job roles needed in sales, services, support, and technical management are:

- Technical trainers
- Subject manner experts
- Program managers
- Project managers
- Engineering managers
- Supply management

For specific skills needs, see **Figure 5**.

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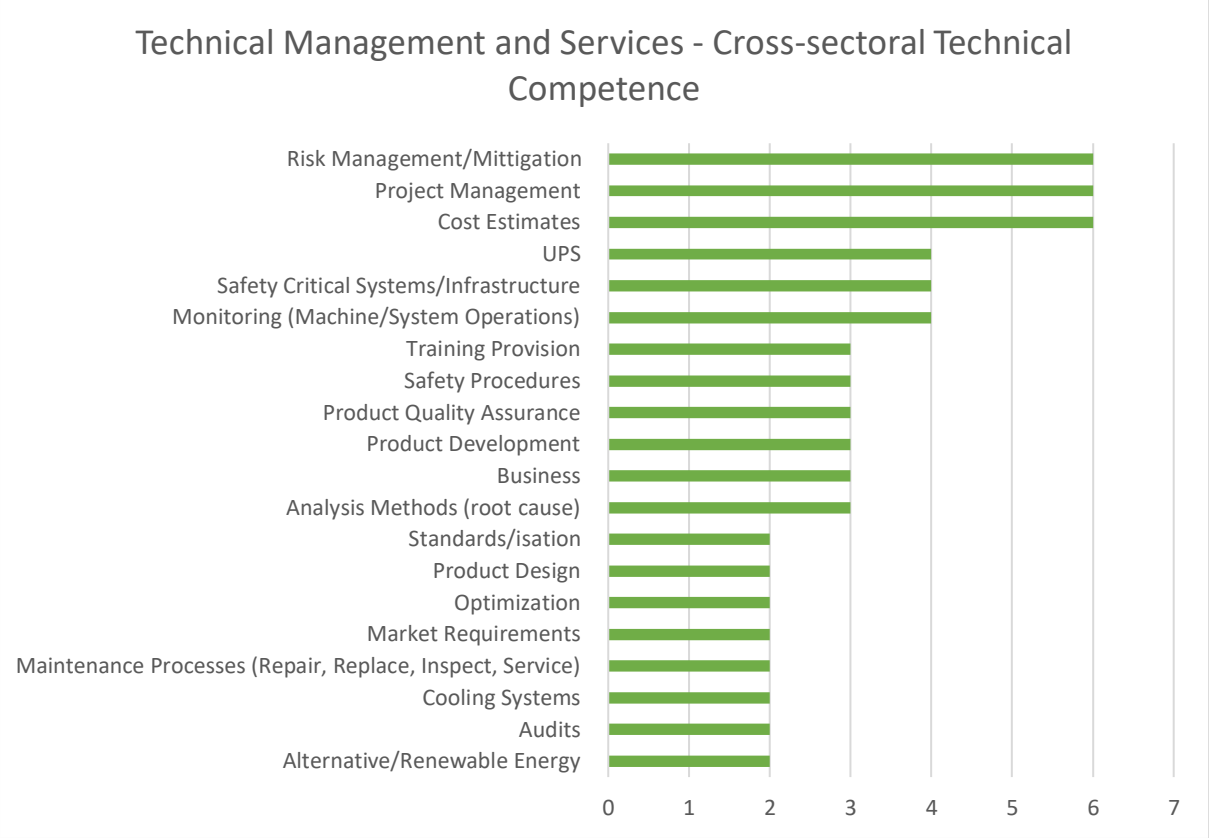

Figure 5: Sales, Services, and Support – Cross-Sectoral Specific Competences Needs

1.1.2 Concrete Recommendations and Considerations

This section provides concrete recommendations and considerations for sectoral development or re-/up-skilling specifically for researched stationary and other industrial applications.

1.1.2.1 Data Centres

UPS/battery skills and knowledge are related to a number of **data centre engineer positions,** such as **data centre engineers, facility controls engineers, electrical engineers, power engineers, service engineers and electrical subject matter experts**.

Maintaining, supporting, and servicing the infrastructure/systems include such engineer and technician positions as **electrical engineers (critical environment), ups battery maintenance engineers, critical facility technicians and critical engineering technicians, data centre support technicians, computer support coordinators and service sales specialists**.

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Various **manager positions** are required **to supervise functions and processes involving UPS/batteries.** They include **critical environment program managers, data centre facility managers, critical facilities managers and project managers.**

When constructing WP4 Desk Research 3, we noticed certain **repeating skills/knowledge** in the data centre/battery job advertisements that should be paid attention to with the education and training of personnel that data centres need.

- **Critical infrastructure expertise** was frequently mentioned.
- Other repeating skills included **battery backup operation and design, battery installation and configuration, applicable electrical codes & standards and BMS with operational experience**.
- **Battery maintenance, including preventive maintenance** in servicing-related jobs, was often mentioned. In this context, we learned the importance of
    - **monitoring batteries**, **identifying weak/faulty batteries (thermal scanning etc.), conduct installation/replacement processes with lead-acid and Li-ion batteries**.
    - Understanding **safety in a data centre** is paramount.

Developing and constructing data centres is an area whose positions require battery/UPS knowledge. They include, for example, **data centre solution architects** and **data centre construction managers**. One must understand the procedures for commissioning a new data centre installation when planning a battery backup system**.**

To have first-hand insight into battery-related skills in jobs data centres, we interviewed a data centre engineer for the WP4 Desk Research 3. The interviewee's position was an **Electrical Subject Matter Expert**. The experience and education preparing for that kind of a role in this example case included

- **low voltage circuitry, electronics, and electricity in general**.
- Additionally, **programming skills** were needed (C++, logical gates etc.).

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About **the employee candidate selection process in general,** we learned that

- when batteries were involved in a job role, **multiskilled applicants were preferred**.
- **In addition to the battery skills, experience in electric cooling, switchgear, other critical infrastructure, circuit-breakers etc., was needed**.

1.1.2.2 Renewable Power Farms

Wind power plants

The wind power jobs requiring battery skills/knowledge include positions in different stages/functions. The stages, positions, and partially the associated skills and knowledge explained below are similar to what exists in the context of solar power farms. What is common with the examples below is that knowledge of and/or skills in BESS technology and related technologies are required basically in all of them**.**

The **project planning and development phase** needs **Managers (Project Development), Engineering & Logistics Managers (BESS), Estimators (Energy storage), Renewable Development Specialists and SCADA Engineers**. The skill and knowledge needs include:

- coordinate engineering activities: contracts, schedules, and budgets
- conduct wind farm due diligence analysis, feasibility studies
- R&D management, product development and design
- Estimate EPC & BOP costs for energy storage system construction projects
- assess renewable site studies, conceptual designs, optimisation, risk managing
- SCADA skills: design, development, implementation, and commissioning phases
- BESS and EMS
- SAT and FAT testing and related documentation

At the **Operation and Maintenance level,** for example, the following personnel are needed: **Managers (Operations and Maintenance), Site Operations Managers, Senior Integration Engineers, BESS/battery Technicians and Supplier Quality Engineers**. The skills, knowledge and tasks of the positions in this level include, for example:

- Develop & lead O&M of wind farm sites incl. Battery Energy Storage Systems

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- Review Requests for Proposals (RFPs), Requests for Information (RFI), Engineering Procurement Construction (EPC) contracts
- procurement of services & materials and working with services contracts
- Audits, analyse quality and qualify or disqualify suppliers
- commissioning energy storage systems and/or inverter-based technology
- ensuring optimal BESS availability and state of health (degradation)
- maintenance & monitoring of the energy storage fleet (managing warranties, BESS components, spare parts, 3rd party service providers/contracts)
- testing, maintaining, troubleshooting, and replacing battery energy storage power plant-related electrical equipment; maintaining battery modules & support systems
- renewable energy experience
- fieldwork supervisory, focusing on Safety, Quality, and Efficiency
- pre-task planning, Job Hazard Analysis (JHA), Risk Assessment (RA)

Additionally, various supporting occupations exist in the areas of, for example, **business development and consulting**. We encountered positions that included **Renewable Energy Consultants** and **Product Managers (Energy Storage Systems – business development)**. The required skills and knowledge regarding **business development** include **supporting sales processes by understanding customer and BESS project requirements**. One has to understand, for example, **BESS use cases and applications, power and energy sizing, reactive power capability, and system operational performance**. Naturally, **knowledge of BESS subcomponent equipment such as Batteries, Power Conditioning Systems (PCS), Energy Management Systems, Power Plant Controllers, SCADA** etc., is required.

The required skills/knowledge regarding **consulting** include understanding **Technical Due Diligence projects (both Wind and Solar Farms, BESS)** and **risk reviews of buy-side/sell-side assets,** as well as having **experience with the development, construction, and operation of renewable energy projects**. In consulting positions, **interpersonal skills** are important.

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Solar power plants

Solar power plants, including BESS, employ personnel in a wide range of occupations, such as those explained below. What is common with the positions listed below is that **knowledge of and/or skills in BESS technology** are required basically in all of them. Many positions appear such that while they existed in the context of solar-related job advertisements, it can be presumed that the positions involving batteries/BESS are very similar to comparable positions in other renewable energy sites. **Thus, the stages, positions, and partially related skills and knowledge explained below are similar to what also exists in the context of wind power farms.**

Solar power plant **construction and project planning and development phases** need such personnel as **Renewable Energy Engineers and Technicians, Project Development Managers, Engineering & Logistics Managers (BESS), Associate Project Analysts (Energy storage Development), Renewable Development Specialists, (Lead) PV Engineers, (Senior) Integration Engineers**, and **Project Engineers (Energy storage).** The skills, knowledge and tasks of the personnel in this phase include various **project management and coordination** roles:

- development of solar and energy storage projects
- management of all stages of construction projects
- coordinating & supporting: engineering activities, project management teams
- manage R&D, support product development and design

Other positions require such skill and knowledge as:

- project analysis
    - Strategically identify and drive project opportunities
    - Support the planning efforts to locate storage assets optimally
    - Evaluate financial models to determine business feasibility
    - knowledge of incentives, ancillary revenue streams
    - engineering principles: power systems analysis, electrical interconnection, BESS, microgrid controls, data monitoring/reporting
- assist in PV & BESS projects, feasibility, and pre-construction/construction phases
- design commercial/utility-scale PV systems, energy storage, microgrids

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- drawings: development, installation/construction and site plan (PV & BESS)
- develop energy production and power system models
- Computer Drafting/Design, AutoCAD, Revit, SKM Power Tools, ETAP
- knowledge of standards
- Supervise sub-contractors
- Coordinating and collaborating with customers, contractors etc.
- knowledge of Data Acquisition platforms and controls systems
- Power generation and system protection and coordination, compliance & relay testing
- knowledge of electricity & hazards
- develop, analyse, and interpret electrical Single- and Three-Line Diagrams
- BESS planning & design, transformer & inverter sizing, power SLD, cable dimensioning, communications & network, component selection, safety
- network technology, SCADA systems, relay protection, HVAC, fire suppression
- commissioning energy storage systems and/or inverter-based technology
- Familiarity with design software and simulation tools

At the **Operation and Maintenance level,** such managers are needed as **Site Operations Managers, Operations and Maintenance Managers, Procurement Managers (senior) - Solar & Battery Storage** and **Solar and BESS Services Engineering Managers.** The skills, knowledge and tasks related to these positions include

- development and leading of O&M at solar farm sites, inc. BESS
- ensuring optimal BESS availability and state of health (degradation)
- maintenance & monitoring of the energy storage fleet (managing warranties, BESS components, spare parts, 3rd party service providers/contracts)
- service & material procurement
- knowledge of battery storage & solar EPC construction services market
- tendering, negotiating, and executing EPC contracts: BESS/Solar Projects
- project viability assessment: CAPEX budget numbers/financial models
- Counsel, Litigation, Procurement; legal support for renewable projects
- provide guidance: design, standards, systems, applicable engineering codes
- develop recommendations for equipment and/or materials selection

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There are various engineer and technician positions in which battery skills/knowledge is needed, such as **Field Service Specialists and technicians, Supplier Quality Engineers, BESS and battery Technicians, Solar Technicians, and Reliability Technicians.** The skills, knowledge and tasks related to these positions include:

- Installation, testing, maintaining, and maintaining battery modules and battery support systems; Preventive and Corrective Maintenance
- Coordinate with Solar & BESS Engineers to develop maintenance plans
- Develop/lead training programmes for the Solar and Battery Storage
- Root Cause, Asset Criticality and Failure Mode & Effect Analysis
- Medium & High Voltage 3-phase power systems, AC and DC power systems, inverters, instrumentation & digital control systems
- knowledge in the use of power plant-related test equipment
- Complete LOTO, Job Safety Analyses, risk assessment
- Experience with SCADA systems
- Audits, analyse supplier quality, root cause analysis and corrective action
- Closed-Loop Quality Management System: Non-Conformance Tracking (MRB), SCAR, CAPA, SQC, COPQ
- SPC, AQP to identify/help implement improvements within Supply Chain Department
- Collect/Analyse/Interpret data from Condition Monitoring technologies

Additionally, various supporting occupations are related, for example, to **business development and consulting** in solar power (and other VRE) systems. They include, for example, such positions as **Renewable Energy Consultants, Battery Energy Storage Systems Specialists and Managers, Technical Asset Managers (Solar and Storage)** and **various positions in Business Development.** The skills, knowledge and tasks related to these positions include:

- Basic technical understanding: Lithium-ion Battery Storage industry
- Understand technical operations of Solar Farm and/or BESS projects
- Experience: Sales or Project Development in Energy storage or solar/VRE (development, construction, operation)

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- working with business models & commercial frameworks for solar and BESS
- identify strengths & weaknesses of business models and incentives
- Understand battery/BESS market trends in technology, applications etc.
- benchmark by analysing pricing mechanisms/costs in leading countries
- develop business & market penetration strategies, BESS opportunities
- undertake Technical Due Diligence projects (Wind and Solar Farms, BESS)
- Risk Review of potential buy-side/sell-side assets
- Strong knowledge of BESS EPC Contracts and Projects
- interpersonal skills, demeanour: ability to interact with high-level executives
- Health & Safety and Quality & Environmental management systems

Hydroelectric power plants

In our desk research, we discovered there were fewer renewable plus BESS-related job advertisements for hydropower compared to BESS-related positions in the context of wind and solar power. We assume that the battery/BESS-related skills needed in wind and solar power farms share similarities with those required for battery energy storage in hydropower systems. The hydropower job roles we discovered included, for example, **engineers** in the following areas/roles: **hydropower mechanical, operation supervisor, hydroelectric power generation, supervisory facilities specialist, project manager, hydropower electrical and structural** and beyond. We discovered, for example, the following roles that appear generic in the VRE area and especially deal with **BESS**: **Engineering & Logistics Manager, Manager of Operations and Maintenance and Supplier Quality Engineer**.

We found, for example, the following skills and knowledge that are related to batteries/BESS in the context of generic renewable energy projects (not limited to hydro, solar or wind):

- **Engineering-related skills and knowledge**
  - manage R&D
  - project management
  - supporting product development and design
  - coordinating and supporting engineering activities
  - Supervise sub-contractors
  - use computer-assisted engineering and design software and equipment

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- **Operations and Maintenance related skills and knowledge**
  - safe and reliable operations of Battery Energy Storage Systems (BESS) projects
  - Ensure optimal BESS availability and state of health
  - Develop and improve technical standards, maintenance guidelines and procedures, equipment manuals, outage procedures, operational protocols, environmental procedures, and other documents specifically dedicated to the energy storage business.
  - Management of warranties, BESS components, spare parts, 3rd party service providers/contracts and other tasks related to the maintenance and monitoring of the energy storage fleet.
  - Participate in the review of RFP, RFI, and EPC contracts for manufacturers, O&M providers, and vendors.
  - At least 3 years of O&M site-level experience with HV, MV, and LV systems.
  - Solid technical background related to the battery storage or energy sector.
- **Supplier quality-related skills and knowledge**
  - perform audits, analyse quality, and qualify/disqualify suppliers
  - initiate Supplier Corrective Actions (SCAR) in partnership with the Engineering, Supply Chain, and BESS departments to ensure complete and effective root cause analysis and corrective action implementation making necessary recommendations and improvements where needed.
  - help establish and deploy a Closed-Loop Quality Management System that includes Non-Conformance Tracking (MRB), SCAR, CAPA, SQC, and COPQ
  - perform ISO audits of Supplier Quality Systems
  - ensure the supplier and Battery Manufacturer has the capacity to produce what has been ordered and what all other customers have ordered
  - promote the use of Statistical Process Control (SPC) and continuous improvement techniques
  - use Statistical Process Control (SPC), Advanced Quality Process (AQP) tools and metrics to help improve the Supply Chain Department

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1.1.2.3 Heavy Work Machines

Mining equipment

During the process, we encountered, for example, the following job roles and skills related to mining equipment and batteries[16][17][18]:

In **developing, producing and purchasing electrified mining machinery,** there are such job roles as **Driveline system engineers (Battery electric vehicles), Electrical, Mechanical** and **Electro-Mechanical Engineers.** Additionally, there are **Systems (Wiring), Manufacturing, Manufacturing Product, System Integration and Technical Support Engineers**. They require, for example, such skills/knowledge as

- understanding heavy-duty mobile equipment
- electric drive line and battery experience/knowledge
- knowledge of system design
- product development
- electromechanical systems for large-scale battery-electric mining vehicles
- power electronics, HV systems and/or subsystems for electric vehicles, batteries, battery charging systems and test equipment
- knowledge of mobile vehicle systems, including powertrain control & BMS, electronic design, analogue circuit design, electromechanical design, high-speed digital circuits
- building & testing prototypes for electric vehicles, batteries, battery chargers etc.
- knowledge of electrical & electronic design principles
- analysis, testing, diagnostics, and root cause analysis of electromechanical systems
- design/analysis of, troubleshooting mechanical and electromechanical products and systems, develop specifications and methods from concept to manufacturing release
- validating components/subsystems/control algorithms: vehicle & powertrain controls, BMS
- low voltage power conversion
- safety

[16] https://www.home.sandvik/en/careers, last accessed in June 2022
[17] https://www.epirocgroup.com/en/careers, last accessed in May-June 2022
[18] https://artisanvehicles.com/careers/, last accessed in May-June 2022

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Regarding **sales processes, after-sales, maintenance/repair services and training**-related technical job roles, they include such positions as **Technical Specialists - Battery Technology**, **Electrification Applications Engineers, Parts Release Engineers**, **Mining Applications Engineers, Factory Product Specialists** and **Field Trainer & Senior Product Masters**. They require, for example, such skills/knowledge as

- providing technical training to partners etc., including repair direction & training
- understanding Machine Life Operating Costs
- Investigating and compiling data on warranty claims
- assisting factories with field testing and trials of new products
- supporting customers in fleet and grid optimisation:
    - calculating electric fleet energy consumption
    - calculating the total cost of ownership
    - understand the PROs and CONs of such mechanisms as battery swapping vs fast charging vs trolley solutions
- understanding mining electrification, applying electric trucks/loaders in a real-world environment
- planning battery charging infrastructure
- developing strategies for deploying solutions to customer projects

Forest machines

Because of the current status of the electrification of the forest machines, we could not find many of them when conducting desk research 3. **Since they resemble other heavy machines, forest machines will likely need similar job roles with similar skill requirements**. The job roles identified in the process are, for example, in engineering positions in product development and manufacturing, including A**pplication Engineers** and **Design Engineers - Battery Technology**. The skills and knowledge they need include

- battery sizing and selection, battery cooling systems, charging systems
- battery systems development (as described below)
- define validation requirements for battery systems
- plan tests
- oversee engineering evaluations of battery systems

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- battery cell chemistry evaluation and selection
- plan innovative changes to existing designs or conceptual thinking to new designs
- intellectual property (IP) knowledge: recognise & document new IP that differentiates the manufacturer's products from the competition
- provide technical expertise and direction related to battery standards and regulations
- provide specifications and analysis for battery thermal management systems (BTMS)
- develop and maintain an understanding of BMS, including necessary operational analysis.

The job roles related to **Maintenance and repair** include **Shop Mechanics, Shop Service Technicians, Field Technicians** and **Motor Pool Technicians**. They need to have the following skills and knowledge about batteries:

- replacing and recharging batteries
- experience with battery chargers
- working on and operations of battery-powered equipment and vehicles

Cargo handling

With the **R&D, manufacturing, sales and marketing, distribution, after-sales services etc., of CHE, a range of battery skills, especially related to Li-ion batteries**, are required. That also includes **charging infrastructure-related solutions**. Based on the level of electrification of CHE, it is clear that battery skills have begun to be an essential part of the job roles. That will be even more the case in the future. The other heavy machines categories covered in WP4 Desk Research 3, and this document also describe **roles with battery skills** that can be assumed to be similar to those needed with the cargo handling equipment. Working with the future generation of non-road mobile machinery will require skills and knowledge, for example, in the following areas: **powertrains, electric drives, electric energy storage, hydraulics, vehicle automation, HMI/GUI, machine control, and digitalisation**. The companies in the CHE business operate globally. That means **intercultural communication skills** are needed.

As an example of what staff is needed for R&D: **Electric vehicle Engineers (Developer R&D)**. The skills, knowledge and tasks required in the position are such as

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- Model-based design approach
- Use the most advanced techniques for functional safety and simulation
- Development & design of electric vehicles in the material handling market
- Electric powertrain design and development
- High voltage vehicle distribution design and development
- Electric system integration
- Electric safety for mobile equipment
- Testing and Validation (EMC, Safety and standards)

Additionally, **Electrical Design Engineers** are needed to meet customers' product requirements. For example, the following skills, knowledge, and tasks are required:

- electrical order engineering
- single line diagrams, schematic diagrams, panel layouts
- preparing electrics by studying customer requirements, calculations for electrics
- Experience in electrical design in the crane industry and material handling industries
- electric design software (E3 schematic, EPLAN, AutoCAD Electrical or similar)
- electrical schematics drawings, mechanical drawings
- Awareness of ISO 14001, 45001 requirements
- understanding of protective devices
- communication skills

There are various **skills and competencies related to batteries needed with CHE in ports and terminals in the planning, development, and implementation phases**. The potential power options for CHE range from diesel to emerging fuels such as Hydrotreated Vegetable Oil (HV100) and hydrogen, all the way to fully electric equipment. Therefore, the management needs to be able **to choose the right power option for future cargo handling equipment** while using renewable energy whenever possible.

One has to be able to plan/create/identify (at a more managerial level)

- a vision and targets, a roadmap, the gap between the present and target state

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- Infrastructure and charging strategy, availability of energy sources, costs, sustainability of energy supply chain
- Eco-efficient solutions, local regulations, availability of maturity of solutions, operational requirements
- Operational scenarios & business case, future, optimal fleet, TCO and ROI calculations
- Implementing and optimisation, training, proactive data-driven maintenance, monitoring progress towards the target state

Designers and planners must also understand **how ports and terminals function** and be capable of **planning the charging infrastructure to support battery-operated machines**. The systems in the charging infrastructure may range from automatic charging stations to manual plugs into the mains. Charging stations may accompany BESS, which acts as an energy buffer. VRE sources such as solar panels can be applied in ports and terminals to maximise the use of green energy. BESS can be used to store the generated green energy, meaning that skills **BESS integration with VRE-related skills** may also be needed.

At the operational level, it is essential to manage the battery charging infrastructure and related solutions and **provide maintenance services and spare parts to the different types of CHE.** With the equipment, **real-time operational information needs to be reviewed and analysed** to enable conducting measures to help improve overall operations immediately. For example, the companies presented in Desk Research 3 provide technical, automation, driving, maintenance, operation, product, and systems training to customers, employees, and dealers**.** The technical training courses ensure **technicians** master all potential issues, from **scheduled maintenance to troubleshooting and repairs**[19]. **Service engineers** should **understand battery systems, know how to change battery modules, and have knowledge of Li-ion battery charging**.

Service Technicians/Service Engineers require skills and knowledge as well as need to work with various tasks as follows:

- work as a team leader

[19] https://www.kalmarusa.com/equipment-services/training/ last aceessed on 18.7.2022

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- assembling, connecting and installing electrical components by following the Accident Prevention Regulation (UVV)
- managing customer meetings
- reporting (for example, fault diagnoses to the quality management and project management teams)
- product quality standards

Heavy construction equipment

When studying the industry's job advertisements for Desk Research 3, we encountered a number of job roles and skills related specifically to construction equipment[20][21][22]. These positions often involve such battery knowledge/skills as

- fundamentals of battery design
- Li-ion or similar battery chemistry and technology
- Experience in Battery Systems incl. charging

We also discovered the occasional occurrence of the following knowledge/skills

- understanding of directives, regulations, and standards applicable to batteries
- Understand Li-ion battery and related technology trends (BMS, applications etc.)
- Understanding and analysing data (for example, related to battery performance)

One of the most interesting findings represents a potentially new kind of knowledge or skill:

- Artificial intelligence and/or machine learning methodologies and application to BMS.

Many job roles, skills and competencies have similarities to the other heavy work machine categories. Some manufacturers manufacture machines in more than one of these categories.

Examples of job roles with related skills, competencies and tasks encountered in the context of construction machinery manufacturers:

- **(Senior) System Design Engineer**
  - design, development, validation of Electrical & Electronic systems and controls
  - design calculations:

[20] https://www.volvogroup.com/en/careers/job-openings.html, accessed in August 2022
[21] https://careers.caterpillar.com/en/jobs/, accessed in August 2022
[22] https://www.deere.com/en/our-company/john-deere-careers/, accessed in August 2022

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        - Electrical Load requirements, Battery sizing, Harness design
    - NPD process, life cycle processes for E&E system components, Batteries
    - Low and High Voltage electromobility systems, components, architecture

- **System engineer Thermal management**
    - Thermal management systems: active cooling for electromobility, batteries, fuel cells etc.
    - the system functionality for both SW and the electrical components
    - system design/engineering, mechatronics/system tools: AD/PLM/Calibration/SW dev.
- **Product Specialist - Driveline and Electromobility**
    - resolving hardware and software-related problems
    - experience in product development: Engines, Transmissions and/or BEV
- **Materials Technology Engineer – Electrical Hardware and batteries**
    - develop stakeholder strategies and devise solutions to boost competitive advantage
    - failure analysis, prototype & prod. parts: electronics, contactors, battery cells
    - material knowledge of electrical HW components, batteries, analytical equipment
    - experience: battery pack degradation, MSc or PhD in materials science
- **(Senior) Engineer – Battery Modelling and Analysis**
    - simulation, development and validation of complex electrical systems
    - battery modelling (Comsol, GTLion 1D/3D, Amesim), simulation, test validation
    - battery management and battery chemistry
    - graphical and computational modelling tools like MATLAB/Simulink/Simscape
    - battery cycler data analysis, battery performance metrics: SoC, SoH, etc.
    - battery management control system, battery thermal simulation
- **Battery Module Performance Engineering Specialist**
    - battery module performance: ensure cooling/heating/charging & discharge HW & SW align with customer requirements and design technical specifications
    - Develop performance test plans, execute/analyse results
    - Experience with electric drivetrain components

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- **Regulatory Project Lead for Batteries, Power Systems Regulatory Engineer**
  - understand applicable directives, regulations and standards that must be met along with other compliance considerations by product and region
  - transportation & storage of HV battery packs, Battery Reuse/Recycling
- **Performance Engineer**
  - vehicle dynamics, linkage kinematics, and machine/soil interaction to optimise performance
  - battery electric models with electric motor drivetrains
  - model machine performance with tools such as Dynasty, SIMULINK or AMESIM
- **Battery Management System Lead/Engineer**
  - lead & execute the development of Li-ion BMS
  - design/develop/test/integrate BMS in energy storage systems incl. Li-ion batt.
  - experience: production and/or product launch of lithium-ion battery systems
  - BMS experience: algorithms incl. SOC, SOH and Safety Functions, software development & validation, hardware design, development, testing, integration of EV applications
  - experience in thermal and ageing models using Matlab / Simulink
- **(Senior) Battery Software Architect**
  - architect embedded software for BMS and integrate control algorithms with appropriate engineering tools and considering the BMS overall requirements
  - experience with developing SW solutions and BMS
  - AI and/or machine learning methodologies and application to BMS

1.1.2.4 BESS in Residential Applications

Residential application BESS requires similar job roles, competencies, and skills as Industrial BESS. However, the particularity of the place of installation of residential BESS requires a different set of skills, mainly in safety, product development and design of the systems. Residential battery systems require certain skills and job positions similar to battery storage systems in other applications. Some of them are mentioned in the list below:

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Power Conversion

- Bidirectional power conversion
- Hardware engineers
- Power electronic engineers
- Control Engineers

High Voltage Systems

- Qualification and training in high-voltage systems
- Materials researchers and Engineers

System Design

- Mechanical Engineers
- Design Engineers
- Product Engineers

BMS

- Algorithm
- Communication Protocols
- Hardware requirements
- Electrical Engineers
- Computer and IT engineers
- IT technicians

Current and Voltage Sensing

- Communication and Hardware Engineers

Risk and Safety

- Risk assessment
- Safety legislation knowledge
- Electrical Engineers specialised in electrical safety equipment and procedures
- Certified Electricians

New Battery Materials and Technologies

- Researchers
- Materials Engineers and Scientists
- Chemical Engineers and Chemists
- Electrochemical Engineers and Scientists

Residential battery systems require **power conversion**, **high voltage systems**, **system design**, **BMS** development and implementation and **current and voltage sensing** skills. They are needed in such job positions [23] as **hardware, power electronics and control engineers** with specific knowledge in the area are critical for the system's success.

Normally, residential application batteries work on 48 V, but the shift to 400 V is becoming popular due to the increasing use of electric vehicles (EVs) and the need for higher energy densities. That shift needs **electricians qualified** with **high voltages**. The power conversion equipment must work in this voltage range safely and with high efficiency as well.

[23] https://www.ti.com/lit/wp/slyy207/slyy207.pdf?ts=1658767316177&ref_url=https%253A%252F%252Fwww.google.com%252F Last accessed on 24.7.2022

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BESS requires attention to the availability of **space** and **cooling**. The Mechanical, Design and Product Engineers' roles in optimising the BESS design are needed.

BMS is an important part of the system. A**lgorithmics**, **communication protocols,** and **hardware requirements** are the skills needed by **electrical engineers** and **computer and IT engineers/technicians**.

The power conversion at high frequencies, the safe functioning of the BMS and other controls require that the challenge of current and voltage sensing is surpassed. **Communication and hardware engineers** contribute to developing fast and precise mechanisms to provide accurate readings that enable a correctly functioning system.

Safety is a growing concern when applying BESS in residential blocks and homes. The risks range from errors in the installation and operation to an electric shock, fire, flash burns, an explosion or exposure to hazardous chemicals and gases.[24] **Risk assessment skills** are crucial in battery companies, and training should be provided to workers and clients of the BESS. The BESS must also be equipped with safety functionalities that allow it to shut down safely. Thus, **Electrical Engineers** specialising in **electrical safety equipment and procedures** with **safety legislation** knowledge are needed in the product design stage.[25]

The installation of the BESS should only be performed, as it is required by law in most countries, by **certified electricians** that should follow the directives provided by the battery and other equipment manufacturers.

[24] https://www.commerce.wa.gov.au/sites/default/files/atoms/files/battery_energy_storage_systems_0.pdf Last accessed on 21.7.2022

[25] https://energystorageforum.com/news/energy-storage/residential-bess-installation-safety Last accessed on 21.7.2022

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2 Building a Gigafactory interview

2.1 INTERVIEW

On the 15th of September 2021, we organised a live interview, "European Battery Ecosystem - Job roles and competencies now and in the future: Building a Gigafactory". The interviewee was **Mrs Katarina Borstedt, Director of Growth at Northvolt**. The purpose of the interview was to gain further information about the challenges of building a Gigafactory regarding the required human resources and their skills and competencies. Earlier, we had covered the anatomy of a Gigafactory in the WP4 deliverable D4.4 (Desk Research 2). Continuing with the Gigafactory topic in the interview was thus useful for gaining up-to-date information.

2.2 SKILLS AGENDA AND RECOMMENDATIONS

The key information generated by the interview included the following:

Recruitment challenges and issues

- There is a **lack of battery experience**.
- Finding **cell developers** requires recruiting from abroad (Asia).
- Challenging to find **expertise in building a factory in greenfield and large-scale production**.
- Job roles and competencies needed in the early stages
    - **Cell design and how the battery looks, its chemistry, and creating a production process around the battery**
    - **Digitalisation-related skills** are also in demand.
- The importance of **experience with battery production** was emphasised.
- With volume roles, challenges with finding **operators** are expected in the future.
- Worldwide recruitment, and they have 85 nationalities currently (a need for cross-cultural and language skills)
- Recruitment process technics developing in the future with **AI, machine learning** etc.
    - To be able to handle volume recruitment efficiently needs a lot of development.

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- They develop ways to evaluate abilities and not only experience and education in a recruitment situation.
- **VR** could benefit them greatly by giving insight into the factory and helping new employees understand the workplace before the first day at work.

Education and training

- They have **summer internships** that work for 2-3 months in different sites at Northvolt. **Many of them become employees after the internship.**
- **Development of the training tools is required.** The workforce needs to be trained in volumes, and they look into introducing more tools, such as those supported by VR.
- It **is important to pilot base educational training setups early on** to ensure that they get the right skillsets for the people that join the company.
- Collaboration with education
  - At the university level, **master's programs for the industry** discussed
  - **Fast tracks for immigrants** with an education
  - **With vocational education, a 20-week training program launched to educate operators to work in an automated industry with a focus on cell production**
  - **An education system is needed for young people interested in a battery industry career and for those in the working life who need re- and up-skilling**
- The **demo production line** in Västerås functions **as a learning platform** from which they can benefit in Northvolt Ett (their Gigafactory in Skellefteå in North Sweden).
  - **Machine operators are needed**, and the Västerås facility is used for training purposes. Most operators have a training period in that facility.

Workforce and its availability

- **75-80 % of the employees are blue collars, and the requirements are getting higher.**
- **Working in an automatised industry is less manual work, and it is about controlling machinery, troubleshooting, and preventive maintenance instead.**
- **Automatisation** is not considered to decrease the need for blue-collar workers**.**
- Many people are needed in production. That is especially the case in the **downstream production in the cell assembly section to monitor, operate, and solve production issues** 24/7**.**
- They will need to create **a good mix of**

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- people with experience in the battery industry,
- people with expertise from other relevant industries,
- people who come from education and
- people who need to be re-skilled.

- Availability of people and the related elements such as housing play a critical role in choosing a location for a Gigafactory
- Supporting systems are essential in attracting people and making them stay longer (especially when they are from abroad and even outside Europe).

Figure 6: Battery Manufacturing - Needed Skills, Competences, and Knowledge

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3 The Impact of The Battery Passport on The Battery Value Chain interview

3.1 INTERVIEW

The "European Battery Ecosystem - Job roles and competencies now and in the future: The impact of the Battery Passport on the battery value chain" event was organised on the 12th of October 2021. The interviewee was Ms Claudia Gamon, a Member of the European Parliament. The purpose of the interview was to have first-hand information from an instance working with Battery Passport. There will be a profound impact of Battery Passport on how data on individual batteries can be accessed and applied in the future. There will also be implications, along with the Sustainable Battery Regulation that it supports, to the future competitiveness of European green batteries.

3.2 SKILLS AGENDA AND RECOMMENDATIONS

The key information generated by the interview included the following:

- **Battery Passport** belongs to the **coming Sustainable Batteries Regulation (thus basic understanding of it is recommended considering the battery-related education)**
- The implementation schedule target: the 1st of January 2026
- Battery Passport is **an electronic record of individual industrial batteries**, also including those in vehicles **stored in a database**
- There will be a **Digital ID card with a QR code** associated with individual batteries
- **Battery Passport provides battery information for producers, consumers, and secondary market**
- Transparency helps consumers to compare batteries and make greener choices
- Leverage the power of the market to support sustainability goals by encouraging producers to
    - monitor their **compliance with the legislation**
    - **innovate climate-friendlier products**
- **Second-life operators can access information via Battery Passport** to plan operations.
- Battery Passport **improves recycling efficiency and supports circular economy**

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- **Harnessing big data** enables governments and producers to use the information to monitor the success and battery market data
- To support the global competitiveness and raw material self-sufficiency of Europe with the Sustainable Battery Legislation
- EU-approved authorities responsible for monitoring the product compliance
- **Batteries imported into the EU have to comply with the legislatio**n. It supports European greener battery producers in operating equally with the competition, which is among the largest questions with **Green Deal and Fit-for-55 packages**.

Figure 7: Battery Passport - Influenced Job Roles

Figure 8: Battery Passport - Influenced Skills, Competences, and Knowledge

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4 Battery Energy Storage Enabling Sustainable Islands interview

4.1 INTERVIEW

The interview and workshop called "Battery Energy Storage (BES) Enabling Sustainable Islands" was kept on the 17th of November 2021. It discussed the opportunities and challenges of installing a Battery Energy Storage System to support the application of VRE and electricity grid in isolated areas and understanding the related job roles and skills. The interview was kept with Mr Duarte Conde Silva, a Plant Manager at Graciólica (Graciosa Island, Azores). The island pursues a hybrid approach to island grid energy generation, combining wind, solar, and energy storage using lithium-ion batteries and thermal generation. The project represents a journey towards a 100 % renewable energy future with an integrated power system combining renewables, engines and energy storage.

4.2 SKILLS AGENDA AND RECOMMENDATIONS

The key information generated by the interview included the following:

- **The application of LTO-based BESS, together with renewables,** has resulted in major improvements in power quality across the islands. Connecting BESS generated massive improvements to voltage and frequency profiles
- **Local utility grid connection to the renewable hybrid power plant** was challenging with different technical approaches and sources
- The plant had to be **designed to withstand unpredictable weather conditions**.
- The main requirement is a minimum of two **electrical engineers on-site** for the current **system optimisation processes** meaning the r**enewable energy optimisation for the grid**.
- Also, **qualified electricians are needed for maintenance**.
- **Electricians are required to have skills in power electronics**.

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Figure 9: Sustainable Battery Energy Storage - Needed Skills, Competences, and Knowledge

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5 Recycling Electric Vehicles' Batteries webinar

5.1 WEBINAR

The webinar "Recycling EV Batteries: Skills and Qualifications Needed in Auto Workshops" was held on the 30th of November 2021, from 10.30 to 12.00 CET. Recycling and circular economy are common areas of interest with WP4 and WP5. Since WP4 had been authoring the recycling topic in Desk Research 1 and 2, this recycling workshop was studied and discussed in the WP4 workshop deliverable.

This event covered the training of the employees, how to benefit from the existing competencies and update them with the new ones that support the circular economy context. Additionally, we looked into employers' preparedness to process the teaching and training of those new skills and what kind of support they expect from the local, national, and European authorities.

5.2 SKILLS AGENDA AND RECOMMENDATIONS

The key information generated by the interview included the following:

- Recycling Li-ion batteries provide important economic benefits, reduces new mineral extraction, increases resilience, and decreases weak steps in the supply chain.
- **The challenges with battery disassembly are many, either legislative or technical.**
- High-voltage batteries need **qualified employees with high-voltage training and special tools for dismantling to prevent electrocution or pack short-circuiting**.
- **Re-skilling/upskilling competencies of employees needed with the circular economy**.
- Batteries are the key enabling technology for zero-emission mobility and energy storage
- **Commission supports identifying strategies for future skills/competencies/job roles**.
- **Knowledge of physical/chemical recycling is needed and supported with environmental skills/expertise, circular economy, and designing battery components.**

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- **The biggest challenges are with engineers and researchers in recycling facility setup—the emphasis shifts from white to blue collars in a later stage of maturity.**
- **The technology and chemical and physical recycling processes need to be educated along with other knowledge and skills.**
- **Design of battery & components by aiming for recyclability** at the end of the lifecycle.
- Innovations and **use of automation in the recycling process**
- The demands of the Battery legislations (content target, competitiveness etc.)
- **Cooperation with academia and VET providers is very important to be developed**.
- For example, the ELVES (Ireland) Core programme and its funding:
    - Collection and recycling of EV batteries from ATFs and aftersales provided
    - Collection and recycling – by marque, as per Batteries Regulations
    - **Training and information support** - by all vehicle producers through ELVES
- **Attention to SMEs in training (battery recycling steps/methods; maintenance/repair)**
- Auto industry OEMs are becoming battery producers needing to deal with recycling
- New versions of the legislation: an ELV directive that will increase the recycling target for LIB and Sustainable Batteries directive to deal with 2nd life, EV batteries, BMS etc.
- **There are two key factors (1) Accredited, recognised certificates on training (worker mobility) and (2) It is important to map the training against the skills that are needed**
- **Apprenticeships are considered an effective training mechanism.**
- **Digitalisation, AI and VR will be essential in the future (already now).**

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Figure 10: Electric Vehicle Recycling - Needed Skills, Competences, and Knowledge

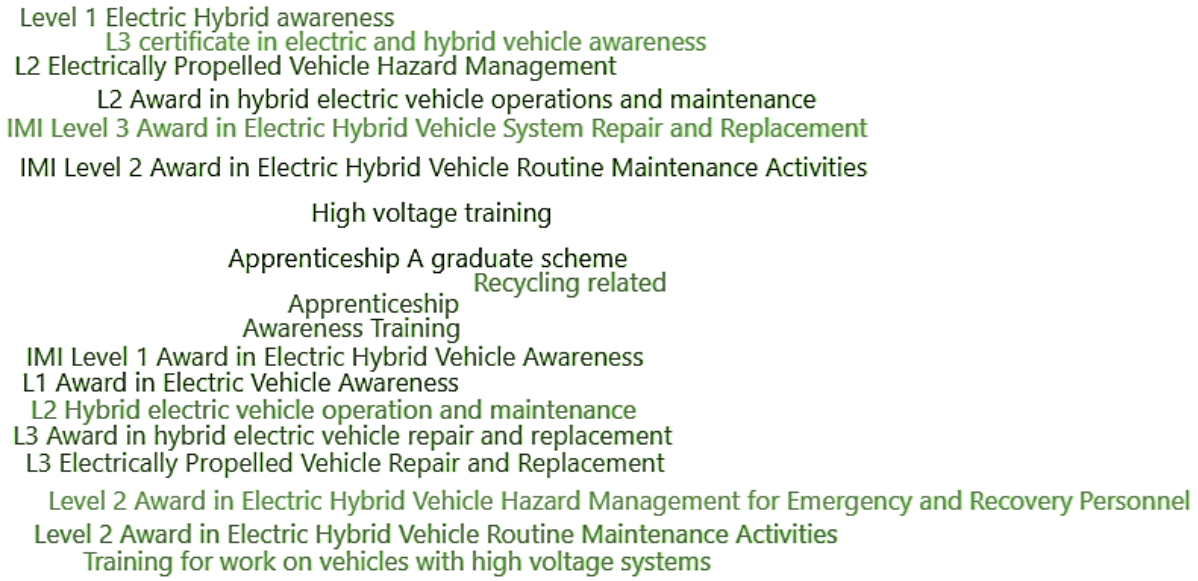

Figure 11: Electric Vehicle Recycling - Needed Training and Education

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