

DELIVERABLE 3.3
INTERIM REPORT ON
STANDARDS & PROTOCOLS
FOR THEORY AND
EXPERIMENT
BATTERY 2030+ CSA3

BATTERY
2030+

At the heart of a connected green society

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TABLE OF CONTENTS

1	Introduction.....	5
2	Report.....	6
2.1	Activities during M1 – M16	7
2.1.1	Concept for an online knowledge base	7
2.1.2	Linking the Knowledge Base with the Battery Interface Ontology (BattINFO)	7
2.1.3	Setup of the Knowledge Base based on Open Semantic Lab	7
2.1.4	The Functionality of the New Battery Knowledge Base	8
2.1.5	Demonstrator project BIG-MAP Coin Cell Assembly SOP and Cycling protocol	14
2.2	Outreach & Visibility.....	15
2.3	Future Work	16
3	Conclusion	17

1 INTRODUCTION

To achieve the ambitious goals outlined in the Battery 2030+ roadmap, research within the initiative—and ideally beyond—must adhere to the highest standards for data generation, processing, storage, exchange, and metadata management. A key objective of the initiative is to support the battery research community in developing effective research data management (RDM) strategies, tools, and consensus-based standards for both experimental and theoretical research.

By integrating RDM tools and standardization, Battery 2030+ aims to enhance research quality and fully implement FAIR data principles. More importantly, this approach will enable unprecedented levels of collaboration, fostering innovative, autonomous research methods, accelerating materials discovery, and advancing data-driven research beyond traditional trial-and-error approaches.

This report D3.3 shows the results of Task 3.3 “Collect and formalize standard protocols for theory and experiment” in the Work Package 3 “Common Best Practices in Battery Research” of the Battery 2030+ CSA3 during the first 16 months of the project M1 to M16 (Sep. 2023 to Dec. 2024).

The work in this report builds upon the results reported in D1.5.1 and D1.5.2 of the Battery 2030PLUS CSA2 which had been running from Sep. 2020 to Aug. 2023.

2 REPORT

Standards and protocols are crucial in research and innovation, in particular in application-oriented, trans-disciplinary fields such as battery research:

Consistency and Reproducibility - Standards define clear and uniform methodologies for conducting research, ensuring that experiments and analyses follow established procedures. This uniformity enables researchers to achieve consistent results across different studies and institutions. Reliable reproducibility is a cornerstone of scientific integrity, allowing others to validate findings by replicating experiments under the same conditions. This fosters transparency and builds trust within the scientific community, as researchers can confidently rely on the accuracy and reliability of each other's work. Moreover, reproducibility is essential for identifying errors, refining methodologies, and advancing knowledge in a systematic manner.

Interoperability - In modern research, collaboration across disciplines, institutions, and even nations is critical. Standards enable interoperability by defining common formats, structures, and communication protocols for data and systems (see also Deliverable 3.2 of this project). This ensures that diverse technologies, software, and datasets can interact seamlessly, avoiding compatibility issues. Interoperability facilitates the efficient sharing and integration of information, which accelerates progress and minimizes duplication of efforts. For instance, researchers can combine data from multiple sources or apply shared tools to address complex challenges, making collaboration more productive and impactful.

Comparability and Benchmarking - Standards provide a shared framework for evaluating outcomes, methodologies, and technologies across studies. This comparability is vital for benchmarking, enabling researchers to assess the performance, quality, and safety of their work relative to others. By using standardized metrics and procedures, researchers and innovators can make informed decisions, identify best practices, and understand the broader implications of their findings. For policymakers and stakeholders, this comparability helps assess the societal or industrial impact of new technologies, supporting strategic planning and resource allocation.

Safety - Research often involves handling hazardous materials, technologies, or processes, posing risks to researchers, participants, and the environment. Standards establish safety guidelines that outline best practices for minimizing these risks. They include protocols for proper handling, storage, and disposal of materials, as well as safety measures to prevent accidents or contamination. Adhering to such standards protects not only individuals but also institutional reputations and ensures compliance with legal and ethical requirements. A strong emphasis on safety enhances confidence in research processes and outcomes, making them more robust and socially responsible. Standards also streamline commercialization by ensuring compliance with industry regulations, easing market adoption, and supporting innovation through iterative updates that reflect new scientific and technological advancements.

In collaborative research projects like Battery 2030+, iterative standardization processes provide specific benefits as they enable novel research approaches, accelerated material discovery, and data-driven science beyond traditional trial-and-error methods. Further, they provide a basis for implementing FAIR principles (Findable, Accessible, Interoperable, Reusable) to enhance data sharing and reliability. Ultimately, standards foster collaboration, reproducibility, and adaptability, providing a robust framework for efficient, credible research and innovation.

The standardization efforts in Battery 2030+ focus on (i) raising awareness about data sharing, ontologies, and standards, (ii) achieving consensus on implementation needs and processes, (iii) harmonizing with broader research initiatives to ensure community-wide alignment, and (iv) creating standards that deliver measurable benefits for the consortium and beyond.

2.1 Activities during M1 – M16

2.1.1 Concept for an online knowledge base

During the previous CSA, we developed and implemented a concept for an online knowledge base. It was launched in August 2023 and is still available here: <https://www.celest.de/en/or/layer1>. At this stage 100 percent of the 100 KPIs and 23 percent of the 60 PPs are assigned to measuring techniques. In total 273 measuring techniques for the KPIs and PPs are mentioned with 112 different individual measuring techniques.

During the current project, we have further developed this concept and transformed it into a dynamic online resource which allows the scientific community to create and modify content online in a moderated process. In the following sections, we provide an overview of the functionality of this new version of our Battery Knowledge Base.

2.1.2 Linking the Knowledge Base with the Battery Interface Ontology (BattINFO)

The integration of the Battery Knowledge Base with the [Battery Interface Ontology](#) (BattINFO) helps to create a comprehensive resource for battery research. This effort unifies structured data across diverse domains of battery science and technology and supports interoperability, data discoverability, and improved reusability.

The Knowledge Base serves as a centralized repository for semantically enriched battery-related data. It organizes information on materials, components, testing protocols, and performance metrics to support advanced queries and analytics. Built on linked data principles and ontology-based modelling, the Knowledge Base provides a holistic view of battery systems, ensuring data standardization and interoperability.

BattINFO complements this framework by providing a specialized ontology for describing batteries, their components, and related workflows. Integrating the Knowledge Base with BattINFO involves aligning their ontological structures, enriching data with BattINFO terms, and enabling advanced query capabilities through federated SPARQL endpoints. This approach allows researchers to leverage high-level conceptual knowledge in BattINFO alongside the detailed, instance-level data in the Knowledge Base.

By linking the Battery Knowledge Graph with the Battery Interface Ontology, this resource lays the groundwork for an interconnected, semantically rich ecosystem for battery data. This integration advances Battery2030+ objectives, fostering innovation in battery research, enabling robust digital twin development, and driving data-driven scientific progress.

2.1.3 Setup of the Knowledge Base based on Open Semantic Lab

The upgraded knowledge base builds on top of [OpenSemanticLab](#) as an object graph. Concepts of the previous knowledge base were translated to linked object schemes (see [OO-LD](#)) with fundamental (e.g. Unique identifier, label and description, ontology-iri) as well as specific properties that interlink the concepts.

The previous database was parsed as excel workbook with Python (using the [OpenSemanticLab Python Package](#)) in order to create linked data objects and upload them to the knowledge base.

Once uploaded, generated entities have dedicated pages in the Knowledge Base and can be maintained (or newly created) which a graphical user interface. Visualization is provided by rendered info boxes, links and interactive graph networks.

With the defined mapping to RDF access to the data is also provided as a SPARQL endpoint. In additions, a prototypical LLM plugin allows to “chat” with the knowledge base by embedding relevant context via RAG, including uploaded files.

2.1.4 The Functionality of the New Battery Knowledge Base

The new version of our knowledge base is available online at: https://battery.knowledge-graph.eu/wiki/Main_Page It was created and launched collaboratively with Fraunhofer ISC and SINTEF. Besides an implementation of the contents of the old version (battery research and development chain with key performance indicators and process parameters), the new platform features information on the entire spectrum of battery-related information, now also including events, people, organizations, and research projects. With this more holistic approach, the knowledge base now aims to become a much more comprehensive information and exchange platform for battery researchers and engineers.

Below, we highlight specific parts of the Knowledge Base and explain its basic functionalities.

Starting Page

Link to the starting page of the Battery Knowledge Base: https://battery.knowledge-graph.eu/wiki/Main_Page

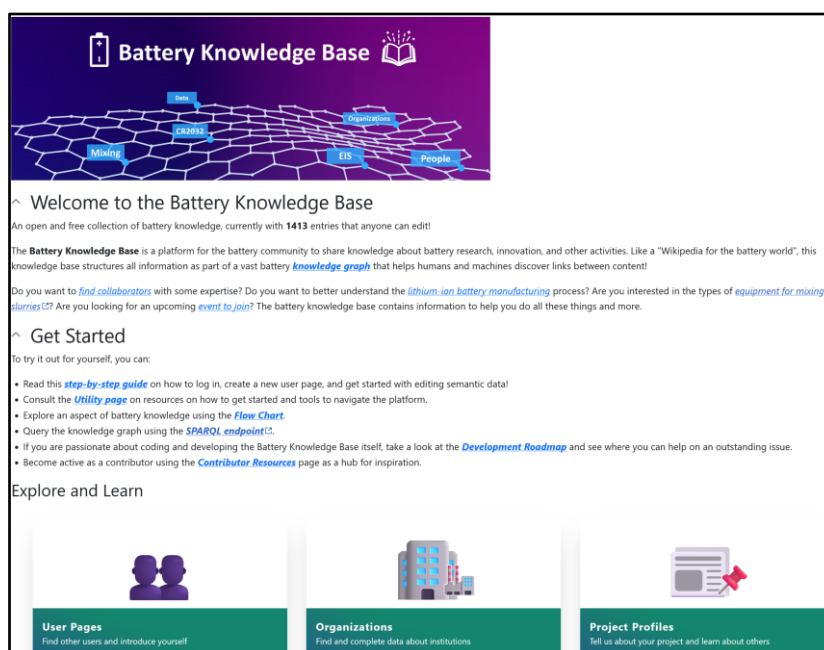


Figure 2.1: Screenshot of the starting page of the Battery Knowledge Base (taken 03.09.2024)

The starting page (Figure 2.1) has the top priority to provide an easy entry for new users. After logging in with their ORCID iD on the bottom left of the window, users have the opportunity to edit the whole content of currently over 1400 entries in the Knowledge Base. On the starting page, features such as “find collaborators”, “explore the lithium-ion battery manufacturing process”, “equipment for mixing slurries”, “join an event”, “create a user page and introduce yourself” are highlighted to spark curiosity and find out more and contribute to the content. In the “Explore and Contribute” section they find quick links to content like “user pages”, “Organizations”, “Projects”, “Events”, “Process Parameters” and “Key Performance Indicators”. Other features shown on the start page are links to utility page, a simplified version of the Knowledge Graph, a Flow Chart, an Entity List of all entries in the Graph, Developer Resources, information about SPARQL Query

Interface and SPARQL Endpoint, Disclaimer about the previous work to develop the Knowledge Base and the specification of the Funding used to create it.

Knowledge Graph

Link to the full Knowledge Graph: <https://battery.knowledge-graph.eu/wiki/Item:OSWd00e7453f1f34a6e94e63c2664fb7776>

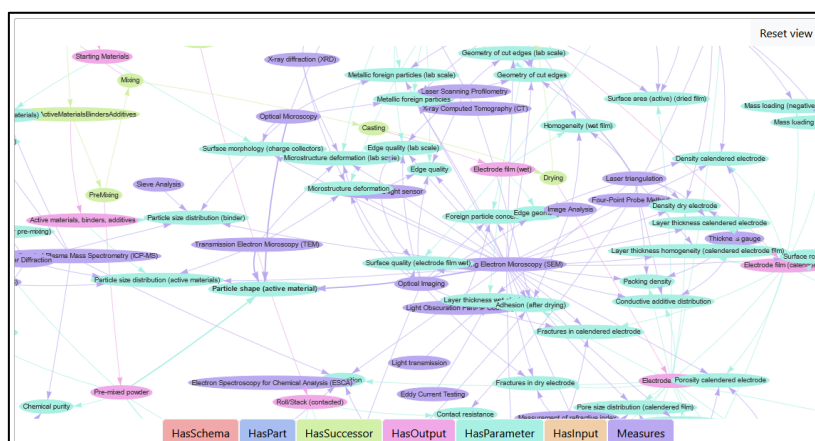


Figure 2.2: Screenshot of an excerpt from the full Knowledge Graph with measuring techniques.

As in the work already accomplished in the CSA2 the information gathered in this work package can be systematically visualised in a knowledge graph of linked ontologized data. On the start page a simplified version is shown without the “measuring techniques” that can be used to determine the parameters. The full knowledge graph (Figure 2.2) starts with the process “**Mining, Recycling & Synthesis**” and goes all along the process chain to “**electrochemistry**” and “**post mortem analysis**” of the full battery cell. For each “process” (*HasSuccessor* of Mining/Recycling/Synthesis) in the value chain there is a product (*HasOutput*). Each product has a number of Key Performance Indicators (KPIs) (*HasParameter*) that can be measured with a measuring technique. By right clicking on one entry in the graph you get a menu with more options (Figure 2.3). For every process you can also display “*DependsOn*” and get the links to the KPIs from previous products that are affecting this process.

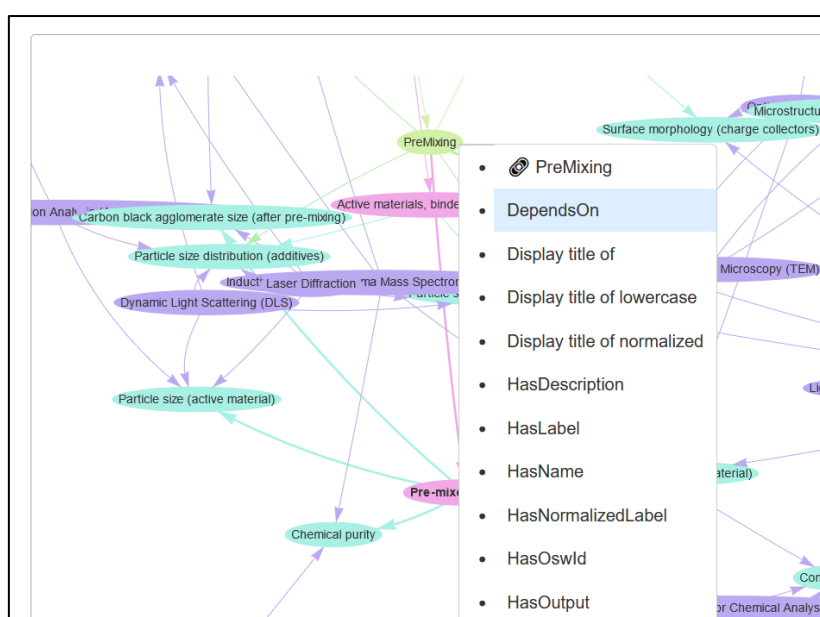


Figure 2.3: Screenshot of the interaction possibilities in the graph.

Other pages in the Knowledge Base that are not directly linked to the battery manufacturing process have a graph. The article type *Organization* shows the *SubClass* in the graph (Figure 2.4).

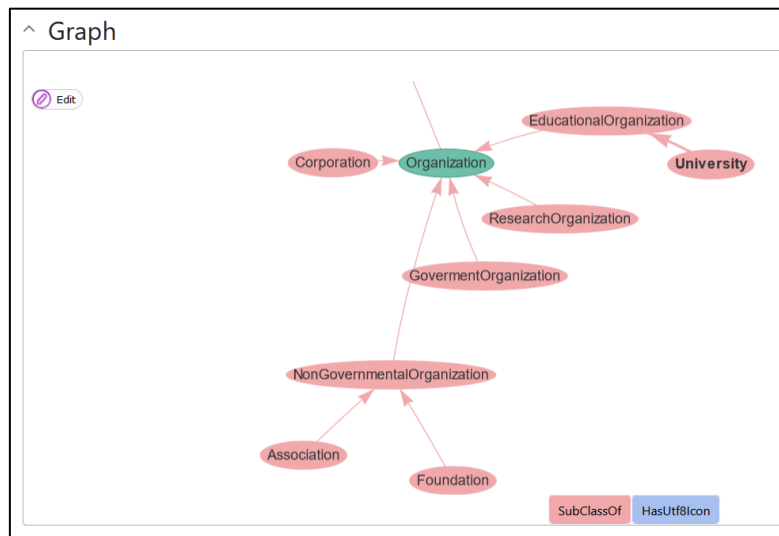


Figure 2.4: Graph vie of the category Organization.

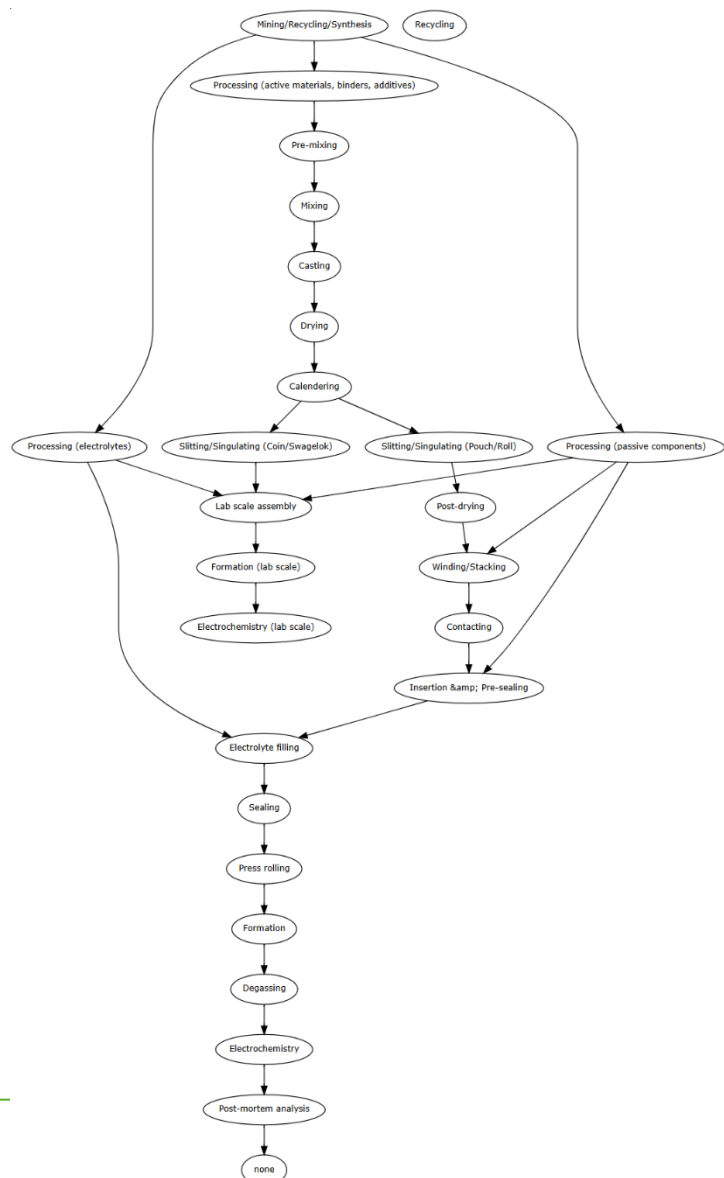
Flow Chart

Link to the flow chart:

<https://battery.knowledge-graph.eu/wiki/Item:OSW7a25cb3789a049f19babc7a7ea0f905b>

The flow chart is a simplified version of the knowledge graph that shows all the processes in the battery research and development chain. The flow chart is interactive and clicking on one of the processes leads to the specific page.

Figure 2.5: Flow Chart of the processes in the battery research and development chain.



Measuring Techniques

Link to the Measuring Techniques: <https://battery.knowledge-graph.eu/wiki/Category:OSW3684c31643ea491b90ea885db9ae864e>

The core of the knowledge base and Task 3.3 is the collection of standards and protocols for experiment and modelling. Therefore, we gathered over 205 measuring techniques to quantify the parameters during the battery research and development chain.

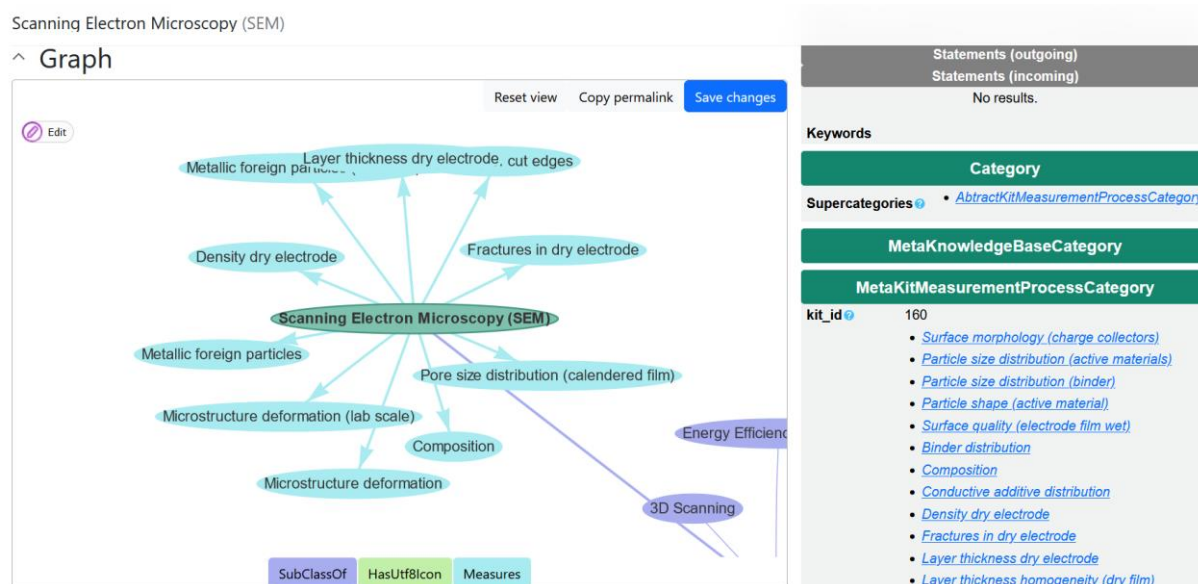


Figure 2.6: Graph of the measuring technique Scanning Electron Microscopy showing all linked KPIs

For example Scanning Electron Microscopy (SEM) ([Scanning Electron Microscopy \(SEM\) - Battery Knowledge Base \(knowledge-graph.eu\)](https://battery.knowledge-graph.eu/wiki/Category:OSW3684c31643ea491b90ea885db9ae864e)) can be used to measure 31 different Key Performance Indicators (KPIs) (Figure 2.6). In the future the users of the knowledge base can contribute their own procedures for each measuring technique and together find a common protocol to boost collaboration and innovation.

Processes

Link to all processes: <https://battery.knowledge-graph.eu/wiki/Category:OSWdc0857e150454dd3a1e45ce54e9b2903>

Currently 26 processes are shown in the flow chart and in the knowledge graph starting from *Mining/Recycling/Synthesis* going along *mixing, casting, drying* and many more to end in electrochemistry, post mortem analysis and closing the loop with recycling. The whole process chain shown in the knowledge base is chemistry neutral, cell format neutral and scale neutral (lab-scale, pilot-line-scale/ industry-scale). Depending on the cell chemistry and the cell format used the real processes the processes will vary and some steps can be omitted. The process chain shown in the knowledge base splits up in lab scale assembly for coin cells and Swagelok cells on the one side and post drying, Winding/Stacking, etc. for cylindrical, pouch and prismatic cells. In the future the process chain could also be modified for upcoming new formats.

Products

Products of the processes: <https://battery.knowledge-graph.eu/wiki/Category:OSWd4b4c5bdb4c54bae815f1a11b62288d3>

After each process in the process chain the resulting product is shown in the knowledge graph. At the moment 26 products are part of the knowledge base. This could also be extended in the future.

Process Parameters (PPs)

List of all Process Parameters (PPs): <https://battery.knowledge-graph.eu/wiki/Item:OSWcb317bb1fee84d81b4b9b3d1d8037719>

Each process in the process chain is defined by PPs that can be measured during the process or that can be adjusted at the machine used for this process.

List of all KPIs

List of all Key Performance Indicators (KPIs) <https://battery.knowledge-graph.eu/wiki/Item:OSW65f139c98efa499b94537f8a15f2be77>

The knowledge base contains 103 KPIs connected to the individual processes in the process chain. For each KPI one or more measuring techniques are shown to measure this KPI. Each KPI is affecting one or several processes later in the process chain. All this links can be displayed in the knowledge graph.

Projects

List of all projects: <https://battery.knowledge-graph.eu/wiki/Category:OSWb2d7e6a2eff94c82b7f1f2699d5b0ee3>

The knowledge base has many other additional features that can be used by the European battery community to gather and share knowledge and boost collaboration. One great feature is the opportunity to list EU funded projects. This can be a running project or also a past project. Currently 28 EU funded projects are listed in the knowledge base. In the Gantt Chart view (Figure 2.7) In the project description of the Battery 2030+ project all past and current projects belonging to the large-scale research initiative are listed: <https://battery.knowledge-graph.eu/wiki/Item:OSW6499d04ced9649f8bbc50f1e940a50c8>



Figure 2.7: Gantt Chart view of all EU projects in the knowledge base

Organizations

Link to the category organization: <https://battery.knowledge-graph.eu/wiki/Category:OSW1969007d5acf40539642877659a02c23>

In the description of a project, it is possible to list the members of the consortium. To better describe the background and expertise of a consortium member the category organization allows to make a detailed page about an organisation. There are different subcategories to choose like corporation, educational organization, government organization, non-governmental organization, and research organization. It is also possible to add another subcategory. Currently 140 organizations are listed in the knowledge base.

Events

Link to the category Event: <https://battery.knowledge-graph.eu/wiki/Category:OSW0e084decca6f48a7b023d6b7b2c1452d>

The number of events connected to batteries are growing rapidly in the last years. To stay up to date and get an overview of the events and pick the most important ones to present your research and connect with other researchers the category “events” has a timeline view (Figure 2.8). New events can be added by everyone and a summary of the event can be uploaded afterwards. It is also possible to upload presentations from the event that are open to share with everyone. Currently 15 events from 2024 are listed in the knowledge base.

Persons

Link to the category persons: <https://battery.knowledge-graph.eu/wiki/Category:OSW44deaa5b806d41a2a88594f562b110e9>

In this part of the Online Resource, researchers have the opportunity to create personal profiles. From synthetic chemists, theoretical chemists, electrical engineers, solid state physicist, life cycle assessment analysts to experts in programming, large language models, machine learning and artificial intelligence a broad range of expertise is covered. To share your expertise and knowledge with other users and find new ways of collaboration researchers can add their user profile in the knowledge base. Currently, only 23 user profiles are listed in the knowledge base – a number which we expect to sharply rise as the use of the new Knowledge Base will be advertised and advocated.

User list

List of all registered users: <https://battery.knowledge-graph.eu/wiki/Special:ListUsers?username=&group=&wpsubmit=&wpFormIdentifier=mw-listusers-form&limit=50>

This list shows all users that registered to the knowledge base with their ORCID. Some of them also have created a user page. Currently 34 users are registered on the knowledge base.

Development Plan

List of tasks to improve the Knowledge Base: <https://battery.knowledge-graph.eu/wiki/Item:OSW2d384748a6dc45e58f36ce57fd2dfbff>

The development plan gives an overview of open topics and future plans in the development of the Battery Knowledge Base. Everyone can add new topics and see the progress of open topics and can contact the person who is in charge of one specific topic.

Active users list

Link to the active user list: <https://battery.knowledge-graph.eu/wiki/Special:ActiveUsers?username=&wpFormIdentifier=specialactiveusers>

The active user list can be used to display actions from the last 30 days to track the progress in the knowledge base.

2.1.5 Demonstrator project BIG-MAP Coin Cell Assembly SOP and Cycling protocol

Link to the BIG-MAP Coin Cell SOP: <https://battery.knowledge-graph.eu/wiki/Category:OSWdaadea83aded5596b806b4f9312c71f8>

The BIG-MAP project has established a first demonstrator project to compare the experiments conducted in different labs of different BIG-MAP partners. The “BIG-MAP Coin Cell Assembly Standard Operating Procedure (SOP)” is based on available literature procedure and was further improved by members of the BIG-MAP project to have a common procedure for all the BIG-MAP partners.^{1,2} The SOP gives a detailed description of the assembly steps, formation, internal pressure, crimping force, electrolyte volume, and the size for cathode, anode and separator. It also gives tips to improve

¹ V. Murray, D. Hall, J. Dahn, *Journal of The Electrochemical Society*, 166 (2) A329-A333 (2019)

² I. Bloom et al., *Journal of The Electrochemical Society*, 163 (14) A2999-A3009 (2016)

reproducibility and shows problems occurred in the past and how to avoid them. The BIG-MAP cycling protocol gives descriptions for the formation cycles and the regular cycles.

2.2 Outreach & Visibility

To increase the visibility of Task 3.3 in the European battery community and also to motivate more members of the Battery 2030+ consortium to contribute to the knowledge base, a poster with the title “Battery 2030+ Knowledge Base – Ontologized Standards and Protocols in Battery Research and Development” has been presented during the Swiss Battery Days on October 2023 on the 4th Battery 2030+ annual conference in Grenoble in May 2024.

In the beginning of 2024, we launched the Battery Knowledge Base 2.0 based on Open Semantic Lab.

CB Battery Ontology and best practices 13.10.2023

In one of the first collaboration board meetings of the new CSA3 the topic of ontologies, standards and best practices was presented by Simon Clark and Philipp Veit to the [HORIZON-CL5-2022-D2-01-02](#) projects [OPERA](#), [OPINCHARGE](#) and [Ultrabat](#) and the [HORIZON-CL5-2022-D2-01-06](#) projects [SALAMANDER](#), [HEALING BAT](#) and [PHOENIX](#). The recording of the presentation can be found on the UU SharePoint and can be used to introduce new projects to the topic.

Simon Stier from Fraunhofer ISC became interested in the task at this point and offered the possibility of a collaboration to connect the existing static knowledge base 1.0 with BattINFO and EMMO to create an ontologized, machine readable and fully interactive version 2.0 of the knowledge base.

The coordinator of the SALAMANDER project Samson Lai from the Institute of Energy Technology (IFE) in Norway is now taking an active role in contributing to the knowledge base.

EUnified Battery Data Workshop 29.-31.01.2024

This three-day workshop organized by BIG-MAP brought together over 50 people from different projects in BATTERY 2030+ to discuss how we can create a framework for an “EUnified Battery Data Space”. Beside data the topics ontologies and standards also played a big role in the workshop.

<https://battery.knowledge-graph.eu/wiki/Item:OSW4fbc7d7f1d2b4e32962102d4380d1b6e>

CB Standards, Ontologies and Best practices 05.04.2024

The Collaboration Board on the 5th of April 2024 had the specific topic “Standards, Ontologies and Best practices” and was presented by Simon Clark, Christian Punckt, Ivano Castelli and Philipp Veit. Participants of the meeting were the [HORIZON-CL5-2023-D2-01-02](#) projects [RENOVATE](#), [ReUse](#) and [REVITALISE](#), the [HORIZON-CL5-2023-D2-01-01](#) projects STREAMS and [CICERO](#), and the [HORIZON-CL5-2023-D2-01-03](#) projects [BatCAT](#) and [BATTwin](#). The presentation was recorded and is available for Battery 2030+ members on the UU SharePoint.

Annual Conference in Grenoble 28.-29.05.2024

During the 4th BATTERY 2030+ Annual Conference at CEA in Grenoble with over 300 participants the topic of standards and protocols was presented on a poster from Philipp Veit and Christian Punckt. Simon Clark gave a presentation with the title “Best Practices the next steps” in which all aspects from the work package 3 were mentioned and also the Battery Knowledge base played a role.

<https://battery.knowledge-graph.eu/wiki/Item:OSW63c92e057309431db7cd0bc5b09420b8>

Battery 2030+ / HYDRA Standards and Best Practices Workshop

During the Battery 2030+ / HYDRA Standards and Best Practices Workshop in Oslo at the 26.06.2024 with over 80 participants the Battery Knowledge Base was presented from Philipp Veit and Lukas Gold. A life demo gave insides into the different features. A total of 17 new users registered during the workshop.

<https://battery.knowledge-graph.eu/wiki/Item:OSW3b40582016064d898bfc762240674edc>

Battery Knowledge Base Webinar

Description of the webinar online: <https://battery.knowledge-graph.eu/wiki/Item:OSW777200d5bcde44d38a5cbea38281a76b>

To engage more people in the Battery Knowledge Base and to give a tutorial about all the functionalities Philipp Veit organized a webinar. Almost 100 people registered for the webinar. The 40 participants were asked in which EU project(s) they are working. Beside the running B2030+ projects there were also 10 other EU projects represented.

Full recording of the webinar: <https://www.youtube.com/watch?v=ijQ1jmuR9JU>

The recording has over 1200 views (as of Dec. 1st, 2024)

2.3 Future Work

Battery Knowledge Base

In the CSA3 the Battery Knowledge Base has made some significant progress in the usability and interaction for users and also machine readability. We added a SPARQL endpoint to the knowledge base. We implemented several ideas to express the data as RDF triples or SQL tables to also allow interaction with the BIG-MAP ontology BattINFO and EMMO (Elementary Multiperspective Material Ontology).^{3,4} Similar work with focus on characterization, testing, and simulation methodology has already been done in BIG-MAP. The plan is to consolidate these activities in the future to get even better results. One of the next steps are to map the terms to standard vocabularies to enable semantic searching and harmonize with similar activities in BIG-MAP.

Connecting the Battery Knowledge Base to ELNs

- Mission 1: create concepts
- Mission 2: download concepts to your ELN
- Mission 3: show people that they have interoperable data
- Mission 4: Whole automatization, conversion tool.

Memorandum on Research Standards and Guidelines

The "[Battery 2030+ Memorandum on Research Standards and Guidelines](#)" was an important first step to agree on a common approach. The memorandum was published in July 2021 and can be signed on the Battery 2030+ website. By the end of the CSA2 in August 2023 we had 91 people from 47 affiliations endorsing the memorandum. As the Battery 2030+ initiative is growing and new projects are joining the memorandum still plays a pivotal role. At the time of this report (30.07-2024) we had 120 people from 56 affiliations endorsing the memorandum. The objective for the future is to share this memorandum not only in the Battery 2030+ consortium, but also in the broader European battery community as part of the Battery Knowledge Base online platform.

³ [D7.1 – Report on Ontology Standards and Development Strategy, BIG-MAP, 2022](#)

⁴ [Battery INTERFace Ontology \(BattINFO\), BIG-MAP, 2023](#)

3 CONCLUSION

The Deliverable 3.3 “Interim Report on Standards and Protocols” outlines advancements made in the Battery 2030+ initiative to establish standardized protocols for theory and experimentation in battery research. This document focuses on the creation of a new and expanded version of the online Battery Knowledge Base, a dynamic resource providing tools for standardising, managing, and interpreting experimental data and theoretical models aligned with FAIR principles. This platform consolidates knowledge on processes, key performance indicators (KPIs), and measuring techniques, supporting consistent methodologies across institutions. Features include a knowledge graph for data visualization, process flow charts, and integration with ontologies like BattINFO and EMMO.

During the first 16 months (M1–M16), significant progress was made:

1. Launch of an improved, interactive knowledge base allowing user contributions.
2. Inclusion of demonstrator projects like the BIG-MAP Coin Cell Assembly Standard Operating Procedure to harmonize experimental practices.
3. Expansion of the knowledge base with information on people, organisations, projects and events.
4. Broad outreach through workshops, webinars, and conferences to foster adoption of best practices and standards.

Future work includes integrating the knowledge base with electronic lab notebooks (ELNs), expanding semantic search capabilities, and promoting the Battery 2030+ Memorandum on Research Standards to encourage widespread adherence to unified protocols. The initiative aims to accelerate innovation, reduce duplication of efforts, and ensure safety and reliability in battery research, benefiting both academia and industry stakeholders.