



CELL-INTEGRATED SENSING FUNCTIONALITIES FOR SMART BATTERY SYSTEMS
WITH IMPROVED PERFORMANCE AND SAFETY

GA 957273

D6.3 DISSEMINATION AND EXPLOITATION PLAN

LC-BAT-13-2020 - Sensing functionalities for smart battery cell chemistries



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| Written By | Silvia Bodoardo (POL) Harald Kren (VAR) Jurgen Garche (VAR) | 30-01-2021 10-03-2021 10-03-2021 |
| Checked By | Silvia Bodoardo (POL) | 29-03-2021 |
| Reviewed by | Maaïke van der Kamp (UNR) Iñigo Gandiaga (IKE) Mette Blom (UNR) | 17-02-2021 25-03-2021 09-03-2021 |
| Approved by | Iñigo Gandiaga (IKE) | 30-03-2021 |
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Summary

The deliverable D6.3 presents the dissemination/communication and exploitation strategies of SENSIBAT project. In addition, first results achieved in the project are also reported.

SENSIBAT project is going to maximise the dissemination of achieved research results and to make understandable also to researchers who are not directly working in the sensors for batteries field and to stakeholders at governments, industry and suppliers, and to generic public.

The SENSIBAT partners will also present results in conferences, fairs, webinars and main results will be published in reviewed journals.

This dissemination plan will be updated during the project and the dissemination activities will be closely tracked.

The SENSIBAT exploitation plan is also presented in this document. Stakeholders will be informed on the results of the exploitation activities run, in order to create possible business opportunities for SENSIBAT partners.

SENSIBAT, as one of the innovative projects under Battery2030plus (www.battery2030.eu) large research initiative, will take advantage to be in contact with the other projects within this initiative focused on sensors development and from the high visibility of BATTERY2030+ initiative.

Due to some internal reorganization of personnel devoted to this Work Package, this deliverable is submitted with one month delay compared to what is defined in the Annex I of the Grant Agreement. This delay has no effect on other task or activities within the project.



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Abbreviations

| Symbol / Abbreviation | |
|------------------------------|--|
| AB | Advisory Board |
| BMS | Battery Management System |
| DOA | Description of Activities |
| EIS | Electrochemical Impedance Spectroscopy |
| GHG | Green House Gas |
| IC | Integrated Circuit |
| IP | Intellectual Property |
| KER | Key Exploitable Result |
| LIB | Lithium Battery |
| NMC | Nichel Manganese Cobalt oxide |
| SEI | Solid Electrolyte Interface |
| SOC | State-of-Charge |
| SOE | State of Energy |
| SOH | State-of-Health |
| SOP | State-of-Power |
| SOS | State-of-Safety |
| WP | Work package |



1 Introduction

This report is dedicated to design the Dissemination and Exploitation Plan following the European Commission's "Communicating EU research and innovation guidance for project participants" to maximise the impacts of the project. The first draft of the Plan is here reported including different strategies for dissemination and communication actions and based on the draft plan shown in the approved project proposal. The objective of the communication plan is to reach out to society showing the impacts and benefits of SENSIBAT project and within the Battery 2030+ Community. The focus is to promote the project among multiple audiences beyond the consortium. The aim of the dissemination strategy is to transfer the knowledge generated and maximise the impacts of the project.

Exploitation activities within the project are directly connected to the dissemination. Stakeholders will be informed on the results of the exploitation activities run, in order to create possible business opportunities for SENSIBAT partners. First Key Exploitable Results of the SENSIBAT project are identified, however, to gauge the potential of these key exploitable results it is needed a better insight on the technologies developed in the SENSIBAT project, this is planned to be done after the first year General Assembly. The Exploitation Plan will be updated on a six month basis, gathering information obtained through technical and commercial surveillance done by each partner.

The plan here presented is a guideline for all partners for dissemination and exploitation activities depending on their specific roles.

During the project, all dissemination activities will be updated by POL and UNR and the exploitation plan will be updated by VAR. An excel sheet will be used to keep track of the dissemination activities. The tracker can be easily reached via a digital form on METT, the online sharing platform.

SENSIBAT is one of the innovative projects under Battery2030plus (www.battery2030.eu) large research initiative. SENSIBAT's will take advantage to be in contact with the other projects within this initiative focused on sensors development and from the high visibility of BATTERY2030+ initiative. Under Battery2030+ specific webinars will be organized focused on new cells functionalities. Strong interaction with stake holders will be guaranteed.

There is a one month delay of this deliverable as given in Annex I of the Grant Agreement, due to some internal reorganization of personnel devoted to this Work Package.



2 Dissemination Approach

2.1 Aim

The aim of the dissemination strategy will be to transfer the knowledge generated and maximise the impacts of the SENSIBAT project. Potential users such as battery, material and components manufacturers, renewable energy producers, automotive companies, scientific community, and policy makers related to the transport and energy sector will be identified.

2.2 Dissemination Strategy

SENSIBAT will place special emphasis on disseminating tangible exploitable results at the right time, that are in line with the European Commission 2050 strategy on net-zero GHG emissions, targeted to the relevant audience.

The dissemination and exploitation strategy will address specifically:

- Exploitable results.
- Relevant target groups, important to deployment of the specific result.
- Specific target groups to be reached through physical or virtual meetings and networking (information days, brokerage events, conferences and webinars, joint workshops with relevant networks) and the publication of information on project activities or results (website, press releases, articles, e-Newsletter, social networks and videos).

The main dissemination activities will be organized as follows and described in this deliverable:

- Design the project branding; logo, leaflet, power point presentation, audio-visual material (UNR).
- Project website (UNR).
- Newsletter (each half year) (IKE, POL, UNR).
- Publication of scientific papers (All partners).
- Participation in exhibitions, trade fairs, scientific and technical conferences and workshops (All partners).
- Organisation of workshops addressing project developments (POL, BDM, FM).
- Dissemination through social media (All partners).
- Collaborate with other projects, Battery2030+ initiative and ETIP Batteries Europe (IKE).
- Exploitation management (VAR).

SENSIBAT promotes dissemination of results defining appropriate timeline along which results are reported and how to disseminate them; using proper message to give adequate visibility and enhancing novelties; creating guidelines for using the developed project identity in the correct way.

2.3 Communication and Dissemination Objectives

The scientific dissemination plan and activities together with the SENSIBAT webpage, the communication towards stakeholders is the main dissemination and communication tool to transfer the project results to various stakeholders.

The material for SENSIBAT dissemination at scientific and technical conferences and fairs or at European workshops and meetings of European associations such as ETIP Batteries Europe or STIP SNET and also to the general assemblies of Battery2030 plus large research initiative.



The Dissemination and Exploitation Plan will ensure open access (free of charge, online access for any user) to all peer-reviewed scientific publications as stated in the Article 29.2 of the H2020 Grant Agreement. Additionally, the Plan will include the measures to follow the provisions included in Article 29.3 Open access to research data and 29.4 Information on EU funding — Obligation and right to use the EU emblem.

2.3.1 Target Groups and Stakeholders

The target group will be enlarged during the project and it will be built starting from well recognized platforms such as BEPA European battery partnership, ETIP Batteries Europe, ETIP SNET EASE, EMIRI, Recharge and Battery2030+ participants, so including already the main stakeholders in the battery field.

In particular, additional stakeholders will be selected from the categories listed below:

- Policymakers
- Business Support Organization
- Academic / Research Institute
- Non-Governmental Sectorial Association
- SME and association of SME
- Industrials

2.4 Dissemination Tools and Materials

The Dissemination and Exploitation Plan will include the tools and materials needed to implement the activities:

- Project website: A specific project website has been launched. The website will be used for communication purposes including events, news, partners, results, etc. The SENSIBAT website URL is: www.sensibat-project.eu (see also D6.2, submitted in M5).
- Project deliverables: All SENSIBAT deliverables are public and accessible in the project website.
- Project branding: a logo, flyer, power point project presentation have been made generating a unique image. A promotional video will be made. More details on this and rules for the correct use of SENSIBAT's project identity are identified in D6.1, submitted in M3.
- Newsletters: each half year to be spread within the networks of the participants.
- Scientific articles: Publication of articles in scientific journals in gold or green open access, participation in scientific conferences.
- AB Workshops: Organisation of two Advisory Board-workshops addressing project developments, discuss the boundaries and how to overcome these, define exploitation strategies.
- Events: Participation in exhibitions, trade fairs and workshops to present the project.
- Social media: SENSIBAT publication of news on social networks of the partners (LinkedIn and Twitter), magazines and websites.
- Battery2030+: Collaboration with projects within the Battery2030+ initiative and through ETIP Batteries Europe.
- SENSIBAT deliverables. The SENSIBAT deliverables will all be accessible to the public and will be published on the SENSIBAT website.

In the following sections, specific tools and materials are discussed in detail.

2.4.1 Project Website

The project website serves as a main tool for communication and dissemination of results. It also provides general information about the SENSIBAT project and its objectives. The website was launched in January 2021 and will be updated on a regular basis. The webpage is available at the URL www.sensibat-project.eu.



Social media plugins for Twitter, LinkedIn, Facebook, and Instagram are available on the webpage to facilitate further sharing and redistribution of the website content.

The website contains information about SENSIBAT and its objectives, work packages and impact. The structure of the website is intuitive and allows the visitor to find the information they need without having to click through many pages. To achieve this, the website is divided into a home page with 4 main subpages: project, results, news and events, and partners, see Figure 2-1 for the website structure. More details can be found in deliverable D6.2.

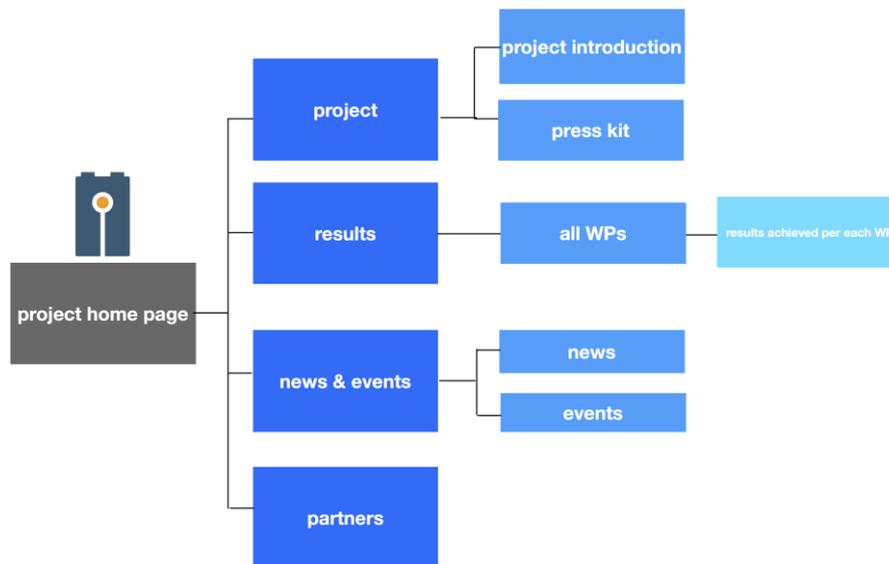


Figure 2-1 SENSIBAT main website structure.

2.4.2 Flyer

To create awareness about the SENSIBAT project, a flyer has been created which can be shared both online and as physical copies. The flyer contains information regarding the SENSIBAT project; partners, contact details, facts & figures, objectives, and targeted impact. All information has been reported in the document D6.2.

The SENSIBAT flyer is presented in Figure 2-2.



FACTS AND FIGURES

SENSIBAT is a research and innovation project aimed at developing a sensing technology for Li-ion batteries that measures in real-time the internal battery cell temperature, pressure, conductivity and impedance of different cell parts.

SENSIBAT is a 3 year EU-funded project launched in September 2020 and is part of the Horizon 2020 Research and Innovation Programme and the Battery 2030+ Initiative.

Start date: 1 September 2020
Duration: 36 Months
EC Funding: 3.3 ME

12 partners from 7 European countries

PROJECT PARTNERS

IKERLAN
www.ikerlan.com
Spain

BEDIENZIONAL
www.bediensional.com
Italy

POLITECNICO DI TORINO
www.polito.it
Italy

FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY
www.fraunhofer.de
Germany

FLANDERS MAKE
www.flandersmake.be
Belgium

TECHNISCHE UNIVERSITEIT Eindhoven
www.tue.nl
The Netherlands

NXP SEMICONDUCTORS NETHERLANDS
NXP SEMICONDUCTORS FRANCE
www.nxp.com
The Netherlands & France

AVESTA BATTERY & ENERGY ENGINEERING
www.avestagroup.com
Belgium

VARTA MICRO INNOVATION
www.vartamicroinnovation.com
Austria

AUSTRIAN INSTITUTE OF TECHNOLOGY
www.aif.ac.at
Austria

UNIRESEARCH
www.uniresearch.com
The Netherlands

CELL-INTEGRATED SENSING FUNCTIONALITIES FOR SMART BATTERY SYSTEMS WITH IMPROVED PERFORMANCE AND SAFETY

www.sensibat-project.eu

CONTACT

Coordinator
Ikerlan S. Coop
Iñigo Gandiaga
igandiaga@ikerlan.es

Project Manager
Uniresearch BV
Maaike van der Kamp
m.vanderkamp@uniresearch.com

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AMBITIONS

- Development of in cell, faster and more extensive sensing technologies for lithium ion batteries.
- Development of more accurate state functions and battery management systems increasing overall safety.
- Cost effective manufacturing of a 24V battery module equipped with a new slave and master BMS using integrated sensors.

TARGETED IMPACT

- Higher safety level & early safety warnings
- Improved battery operation & thermal management
- Extended range by optimal capacity use
- Improved fast charging
- Improved battery maintenance
- Increased lifetime as a result of better battery management & control
- Higher economic value of battery pack for 2nd life usage
- Selective re-use and recycling

BATTERY 2030+

SENSIBAT is part of the BATTERY 2030+ initiative which is a large-scale research initiative of seven projects and a total budget of 40.5 million euros.

BATTERY 2030+ initiates the first phase of inventing the sustainable batteries of the future. The projects will contribute to the implementation of ultrahigh performance, reliable, safe, sustainable and affordable batteries.

www.battery2030.eu

OBJECTIVES

Development of sensing technology

Integration of sensing technology in battery cell

Incorporation of battery cells into a battery module

State estimation algorithms based on sensor data

Cost-benefit analysis and recycling study

Figure 2-2 SENSIBAT flyer.

2.4.3 Audio-visual material

The audio-visual material in the form of a promotional video will be realised to promote SENSIBAT project. This video will be made at the facilities of Flanders Make when the battery module with level 1 sensors is ready (M30). These audio-visual materials will be disseminated through the mailing list, the website, and social media.



2.4.4 Newsletter

Each 6 months, a newsletter will be released with the last updates of the project focusing on the general public, paying special attention to engage young students to science. This newsletter will contain also specialised events, and activities carried out in the frame of Battery2030plus initiative. The newsletters will be disseminated through mailing list, the website, and social media by UNR.

2.4.5 Scientific publications and participation in scientific conferences

Scientific publication and participation to conferences are the best way to disseminate the project technical results. The aim is to present the objectives and results of the project and to share them with the scientific community at European and global level. The consortium aims to show the relevance of sensorised batteries in the field of energy storage and electrical transport. Furthermore, the consortium members aim at showing the scientific community the excellence of the research project. The number of papers published and presentations held at scientific conferences are a good way to measure the scientific success. All scientific publications are peer-reviewed as stated in the Article 29.2 of the H2020 Grant Agreement

2.4.6 AB workshop

Two AB workshops will be organized, addressing project developments, to discuss the boundaries and how to overcome these, and to define exploitation strategies. The overall workshop organisation is done by POL. The first workshop will be organised at the premises of BDM in M18 and the second at FM in M36.

These workshops, together with additional events, newspaper publications will allow the project to be disseminated toward the society and thanks the organization of activities with young students and researchers.

2.4.7 Events, including trade shows and exhibitions

Several events as trade shows and exhibitions will be selected to communicate/disseminate the knowledge – after protection of intellectual property – to the international energy storage and automotive community and beyond. Most partners are directly or indirectly members of the following associations: EMIRI, EARPA, EGVA, EUCAR, EERA, EASE. Many of them participate in the following technology platforms: ETIP SNET, ETIP Batteries Europe. SENSIBAT fits in the frame of proposals as proposed by the large research initiative Battery2030+ and will participate in related events to share knowledge and results achieved during the project.

Presence and presentations (stands, posters and talks) at relevant exhibitions and trade fairs is taken in consideration e.g. AABC and conferences, e.g. VPPC, EVS, Kraftwerk Batterie.

In all organised events, SENSIBAT will promote gender equality in all its actions and activities to promote the recruitment of women for positions related to the execution of the project and to pursue gender balance among speakers in events organised by the consortium.

2.4.8 Social Media

The web 2.0 is nowadays a must in the communication of a project. Every important news is posted and commented on social media, especially Twitter. LinkedIn has more profound discussions where participants reflect and give their opinion about a certain research project or result. For SENSIBAT project, the aim is to attract the attention and spread light on novelties in sensors in battery cells by media and of other stakeholders including the public to the activities of the project.



The personal and company accounts of Twitter, Facebook and LinkedIn of the partners will be used to disseminate the project starting directly from dedicated buttons on SENSIBAT website.

2.4.9 Collaboration with Battery 2030+ Initiative

POL, FHG and AIT are already partners in the Battery2030+ initiative and actively participated in the roadmap writing. POL is also WP3 (Cell integration of sensors) leader in Battery2030plus (Education and New curricula). Moreover, ABEE is involved in the initiative as EMIRI member. This will ensure a good link with the large-scale research initiative on Future Battery Technologies.

All this clearly witnesses how the consortium will collaborate strongly with Battery2030 initiative.

The SENSIBAT project partners concluded a written collaboration agreement with the other projects selected from these topics as indicated in the Grant Conditions. The new Battery 2030 plus strategies also include education topics and definition of new curricula, based also on industrial needs. A part of the project partners is involved in education at universities. The basics of the SENSIBAT project and the other five Battery 2030plus projects may be included in lectures. Part of the common activities within WP3 of Battery2030plus initiative will be to make an overview of which lectures will be updated yearly. These lectures could be used also in advanced training seminars.

2.5 Quantification and Timing of the Dissemination activities

The following Table 2-4 provides a quantification of the project's dissemination activities taken into consideration. Monitoring will be done throughout the project and included in the official reporting at M18, M36 and M48.

Table 2-1 dissemination activities.

| Dissemination measure | Purpose | Key performance indicators | Targeted Audience |
|--|---------------------|---------------------------------------|---------------------------------------|
| Project updates on SENSIBAT website | General information | ≥ 8 updates/year ≥ 1000 views/year | General public |
| Organisation of GA meetings | Knowledge exchange | ≥ 2 meetings/year | Consortium members |
| Organisation of AB workshops | Knowledge exchange | ≥ 2 workshops during project | Energy storage and automotive sectors |
| Participation in conferences, exhibitions, trade fairs | Knowledge exchange | >15 conferences | Energy and transport sector |
| Open Access publications | Research | > 5-10 publications | Scientific community |
| Online publishing (online magazines, newspapers, newsletters, blogs) | General information | ≥ 6 newsletters (half-yearly) | General Public |
| Work out of basic lectures, webinars and seminars | Education | 2 webinar/seminars | University and master students |



Figure 2-3 shows the timing of several dissemination activities.

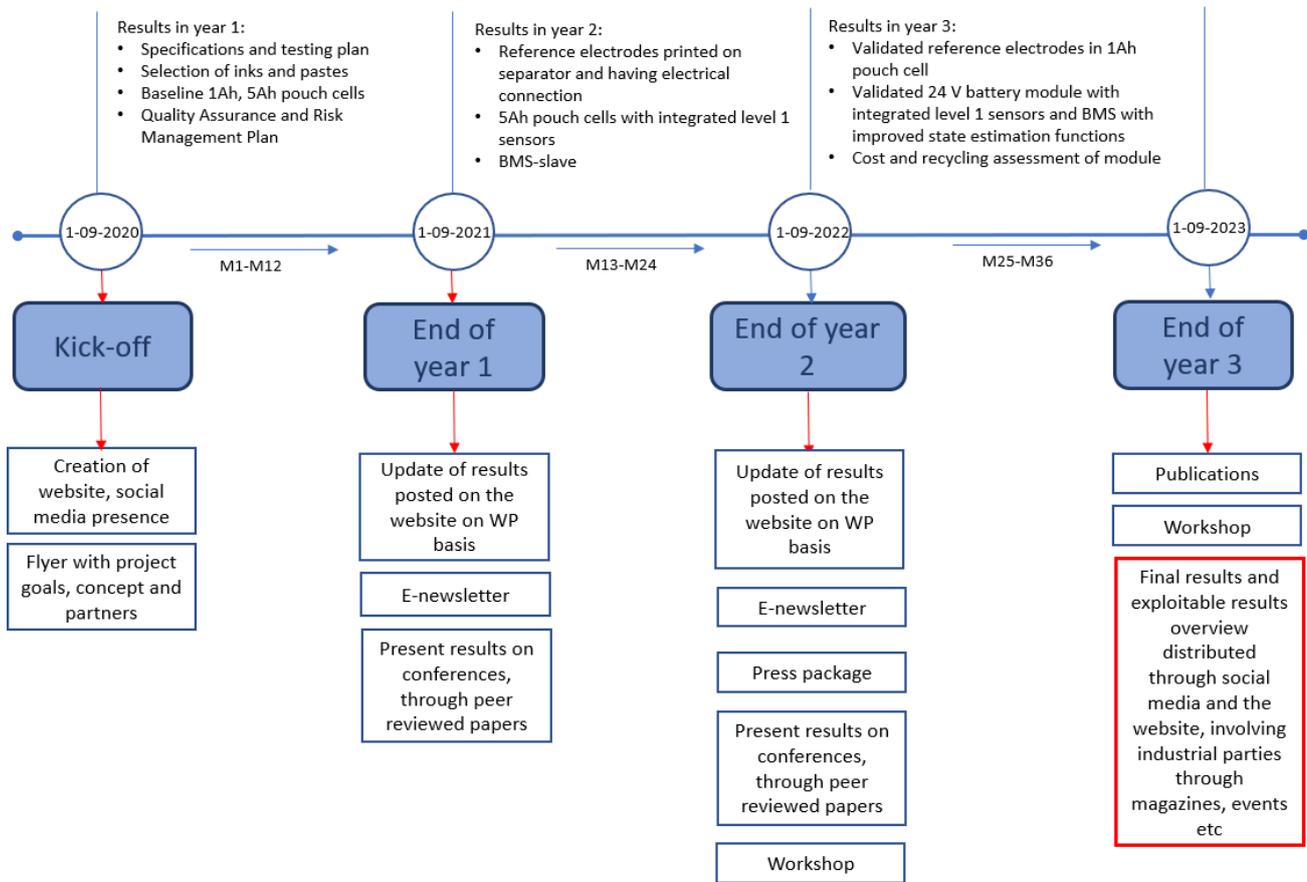


Figure 2-3 Timing of several dissemination activities.



initiative communicated the kick-off of all projects under the Battery2030 umbrella. In addition, articles in national newspapers have cited SENSIBAT, e.g., Il Messaggero 8-2-21 (POL).

The dissemination activities will include (but not limited to):

- Publications in peer-reviewed journal papers (all partners).
- News on SENSIBAT website (UNR).
- Presentation of SENSIBAT results in conferences, exhibitions, and fairs (All partners).
- Dissemination of result achieved to stakeholders during technical events (IKE).
- Publication on national or local newspapers or broadcasts (All Partners).

3.3 Rules for Dissemination and Publication

The rules for dissemination and publication are described in the Consortium Agreement and the Grant Agreement. This plan ensures open access (free of charge, online access for any user) to all peer-reviewed scientific publications as stated in the Article 29.2 of the H2020 Grant Agreement.

3.4 Dissemination Acknowledgement and Disclaimer

Any dissemination activities and publications in the project, including the project website, shall:

- Display the European emblem. When displayed in association with a logo, the European emblem will be given appropriate prominence.
- Include the following statement (from the Grant Agreement, Art. 29.4): "This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 875189."
- Contain a statement that it reflects only the author's view and that the Agency is not responsible for any use that may be made of the information it contains (Art 29.5 of the Grant Agreement).



4 Dissemination achievements and plans

4.1 Website

The website is a key result of the project. It is described in D6.2 and the website will regularly be updated with news and results of the project. The main objectives of the website can be found below.

Main objectives of the SENSIBAT website are:

- Provide updated project information
- Give information and contacts of the project partners
- Inform the general public on the most relevant project results and the current project status
- Offer all publications, broadcasts, etc. for the general public
- Provide links to other events (conferences, workshops, e.g.)
- provide links to activities in common with other projects funded under Battery2030plus umbrella
- Supply contact details
- Publish updated newsletters

4.2 Flyer and newsletter

The SENSIBAT Flyer is ready and available on the SENSIBAT website and on the Mett repository. It is also shown in Fig. 1-3 and described in D6.1. Each 6 months new and updated newsletters will be published on the SENSIBAT website and sent to stakeholders. The first newsletter will be published in M8.

4.3 Project Logo

Several logos were designed and the final logo was selected by voting during the kick-off meeting. The logo represents schematically a battery cell with a sensor inside sending signals to a receiver. It is blue with a yellow circle inside and it is reported in Figure 4-1.



Figure 4.1 SENSIBAT logo.

4.4 Project presentation and audio-visual material

A project presentation is available and sent to all partners. An “official” project presentation will be prepared and organized by the project coordinator with the help of WP leader and systematically updated.

No audio-visual material is available to date: it will be produced at the facility of Flanders Make and available at M30.



4.5 Scientific and Technical Publications

No papers have been published to date. However, three papers related to the project activities have been submitted by BDM to Nature Comm., Chemistry of Materials and Nano Energy.

The first plan for publication is shown in the Table 4-1 First list of journals for publication of SENSIBAT results below. This plan will be updated in METT repository in the proposed excel sheet shown in Fig. 3-1.

Table 4-1 First list of journals for publication of SENSIBAT results

| Business and Scientific Journals | Year/date | Partner responsible/involved | Content |
|--|------------|------------------------------|--|
| Journal of Power Sources Batteries (MDPI) | 2022/20 | POL, BDM | New sensors printed on separators to detect temperature and measure impedance |
| Journal of Power Sources Batteries (MDPI) | 2023 | POL, BDM | New cell configuration including new sensors |
| IEEE Trans. Control Systems Technology / Journal of Power Sources | 2022 | TUE | Spatial temperature distribution and its relation to electrical behaviour |
| Nature Communication | 2021/ 2023 | BDM | Bidimensional materials for sensors |
| Chemistry of Materials | 2021/2022 | BDM | Bidimensional materials for sensors |
| Nano Energy | 2021/2022 | BDM | Bidimensional materials for sensors |
| IEEE Sensors Journal / Sensors & Actuators A /MDPI Sensors | 2021/2022 | FHG | Temperature and pressure sensor processing and characterization/ matrix addressing and readout |
| Journal of Power Sources Batteries (MDPI) | 2022/2023 | ABEE, AIT, VAR | Cells with sensor and Cells without sensors – Comparison of results obtained through ageing/calendar test. |
| Journal of Power Sources (MDPI) | 2023 | AIT | Advanced SoX estimation of LIB cells using smart functionalities |
| Applied Energy (Elsevier) | 2023 | FM | Advanced SoX estimation algorithms based on cell-integrated sensors, incl. experimental validation with battery module |

4.6 Exhibitions, trade fairs, conferences and workshops

A first presentation citing SENSIBAT was given by POL as invited lecture in SIBAE conference (<http://www.sibae2020.uy>) in Uruguay (online conference). BDM already presented SENSIBAT results in GrapheneforUS2021 (<http://www.grapheneforus.com/2021/program.php>) and in Graphene Canada 2020 (<http://www.graphenecanadaconf.com/online2020/program.php?d=17>). Project Coordinator (IKE) also participated and presented SENSIBAT project in the BATTERY 2030+ initiative bi-annual meeting.

The plans for events are shown in the table below.



Table 4-2 First schedule of conferences and exhibitions where SENSIBAT results can be presented

| Conferences and Exhibitions | Year/date | Partner responsible/involved |
|--|-----------|------------------------------|
| IMLB | 2022 | POL, BDM |
| American Control Conference | 2021 | TUE |
| AABC | 2022/2023 | VAR, ABEE, IKE |
| 4th Intern. Li-Battery Safety Workshop | 2022 | VAR, ABEE |
| GrapheneForUs 2023 | 2023 | BDM |
| ISE meeting 2021 | 2021 | POL |
| LOPEC 2022 | 2022 | FHG |
| IEEE Sensors | 2022 | FHG |
| Batteries Event | 2022 | AIT |
| Kraftwerk Batterie | 2022 | AIT |
| Battery Show Europe | 2021/22 | AIT |
| EPE 2022 or AABC Europe 2022 or IEEE VPPC 2022 or IMLB 2022 | 2022 | FM |
| EPE 2023 or AABC Europe 2023 or IEEE VPPC 2023 | 2023 | FM |
| BATTERY 2030+ initiative, bi-annual meeting | 2021 | IKE |
| GoMOBILITY | 2022 | IKE |
| Power Our Future | 2023 | IKE |
| Electric Vehicle Symposium | 2022/2023 | IKE |

4.7 AB workshops

Two AB workshops will be organized. The overall workshop organisation is done by POL. The first workshop will be organised at the premises of BeDimensional in M18 and the second at Flanders Make in M36.

4.8 Collaboration with Battery2030+ Initiative

Active collaborations are running. SENSIBAT will participate in the biweekly Battery2030 meeting and all assembly meetings. At the end of 2021, it is expected that a webinar on new battery functionalities, i.e. self-healing materials and sensors, will be organised. This webinar will be organised within Battery 2030 education frame and SENSIBAT will contribute by reporting its first results.

The SENSIBAT partners who are in charge of the activities within the Battery2030+ initiative can be found below:

- KPI and Project portfolio monitoring: IKE.
- Identify and contribute to guidelines and best practice for data sharing & FAIR Data: IKE.
- Contribute to standardization of protocols for experimental data and for modelling methods/tools:
- AIT.
- Exploitation and Intellectual Property Rights strategy in dialogue with the BATTERY 2030+ research projects: VAR.
- Identify education needs: VAR.
- New European curricula: FHG.
- Young scientist engagement: POL.
- Dissemination and communication: UNR.



5 Exploitation strategy

The European Commission refers to exploitation as: “The utilization of results in further research activities other than those covered by the action concerned, or in developing, creating and marketing a product or process, or in creating and providing a service, or in standardization activities.”

Within SENSIBAT, project partners will identify the strongest exploitation potential of the results at the level of each partner (methodology point 2) and of the project partners as a whole (methodology point 5 and 6). Exploitation will be a vertical component of the project life-time and will be continued even after the end of the project.

Methodology to be used: To ensure that research and industrial partners follow the right exploitation path, the project partners will utilize a predefined procedure (exploitation plan), allowing to carefully analyse each exploitable result and its marketable value. This procedure is:

1. Initially, all Key Exploitable Results (KER's) will be identified. At the present day identified KERs are listed in Table 5-1. In the frame of the first year GA-meeting a workshop will be organized by VAR to update and upgrade the list of KERs (check of validity and completeness). In this workshop, the project's researcher and industry partners will contribute to the KER's list to achieve a target-oriented exploitation of the project outcomes.
In the frame of this workshop a lead partner will be aligned to every identified KER. Furthermore, the involved partners will be determined.
2. The dedicated lead partner will then be responsible to complete a template document. The preparation of this template document is in the responsibility of VAR and will incorporate the following key elements of the exploitation process:
 - a. KER title
 - b. KER description (1/2 to 1 page)
 - c. Technical Results (1 to 2 pages, including figures)
 - d. Exploitation per partner (2 to 3 pages)
 - Nature of exploitation
 - Form of Exploitation
 - Detailed description of exploitation
 - e. Background/Foreground Knowledge Analysis
 - f. Risk Analysis (including risk and mitigation strategies)
 - g. Joint-ownership management
 - h. Intellectual Property management
 - i. General conclusion
3. It will be the responsibility of the dedicated lead partner to complete the KER document, supported by the involved partners. VAR will collect these documents and comprise them in one report, the exploitation plan. This document will include the information gathered by the partners on areas, sectors or agents outside the consortium that could be interested in exploiting the results. The report will also provide information by the industrial partners on market needs. With this information the project partners will be able to assess the market potential and barriers. In this context also enablers and constrains for the exploitation can be determined.
4. The exploitation plan will be updated each 6 months by the lead partners.



5. In the frame of the AB meeting at month 18 (D6.4) the exploitation status based on this report will be discussed and necessary measures to promote the exploitation e.g., with industrial partners will be undertaken.
6. Update and further evaluation of changes will be continued to the end of the project and the outcome will be discussed again in the frame of the final presentation at the AB meeting at month 36 (D6.5).

Table 5-1 Identified KERs at the present day (to be announced -tba.)

| KER No. | KER Title | Lead partner | Involved partners | Main innovation. |
|---------|---|--------------|----------------------|---|
| 1 | Smart battery cell sensor technology | Lead partner | Project partners | Working principles L1S: Temperature and Pressure measurement on lab level Working principles L2S: impedance measurement on lab level |
| 2 | In pouch cells integrated sensors | VAR | ABEE, AIT | Cell integration of L1S Cell integration of L2S |
| 3 | 24 V battery with integrated cell sensors and BMS | tba. | tba. | 6 cell battery with integrated L1S and L2S as well as BMS |
| 4 | Model for state estimation functions based on results of cell/battery measurements with sensors | ABEE | tba. | Models for predictions of SOC, SOH, SOE, SOP, SOS |
| 5 | Analysis of cost of sensing technologies and applicability into cell manufacturing | ABEE | FM, FHG, NXP-FR, AIT | Cost model for sensing technologies Manufacturing analysis for cell sensing technologies |

5.1.1 Exploitable results determined at project start

1. Smart battery cell sensor technology

- IBDM and POL will develop a 2D sensor matrix capable of sensing the spatial temperature and pressure (strain) in the battery cell. These sensor technologies have been developed and validated by FHG up to a TRL-level of 4 for application in optical applications (Temperature sensor) and touch controllers (Pressure sensor). In SENSIBAT, the spatial temperature and pressure (strain) sensor matrices will be encapsulated to withstand the chemical environment of the LIB cell. The temperature and pressure sensor matrix will be connected (via wiring) to an existing NXP IC to read out the sensors. The required cell adaptation for the integration of these sensors is part of sub-objective 2. These sensors are called the “level1 sensors”. The targeted accuracy of the temperature sensor is $\pm 1^\circ\text{C}$ over a temperature range of $-20 - +60^\circ\text{C}$. The pressure sensitive device will detect forces up to $1,500 \text{ kN/m}^2$ with an accuracy of $\pm 1\%$ of the maximum value. Sampling rate of temperature and pressure sensors will be $> 0.2 \text{ Hz}$.
- Internal sensing (auxiliary) electrodes, printed on the separator positioned between the active anode and cathode and placed inside the battery cell. Two different types of such “sensing” electrodes will be developed:
 - i) electrodes to perform in-situ Electrochemical Impedance Spectroscopy (EIS) tests, which can indicate several internal processes like ion diffusion, charge transfer and the evolution of the solid electrolyte interface (SEI) and ii) electrodes for in-operando EIS to measure the electrolyte impedance and its change during the cell operation. These internal sensing electrodes are called the “level 2 sensors”. The level 2 measurements result in more in-depth understanding of underlying ageing and failure mechanisms which will improve the control capabilities of the Li-ion cell parameters. By this, safe operating conditions during fast charge/discharge conditions can be maintained, the overall cell lifetime will increase, and accurate estimation of the battery state will be obtained.



2. Integrate the sensor technology in (pouch) battery cells.

The developed sensing technologies will be integrated by FHG together with AIT, ABEE and VAR inside 1 and 5Ah lithium ion (graphite, NMC) pouch cells. The level 1 sensors will be connected to the NXP multicell monitoring IC (integrated circuit) outside the battery cell by a wire-based interface (the read-out electronics and serialisation of data will be implemented inside the battery cell), for the level 2 sensors flat electrical connections will be developed. To feed the wires out of the battery cell and seal the exit, a barrier layer of adhesive polymers and absorbent materials will be developed. The key results for this sub-objective are:

- Novel pouch cell design with integrated sensors that do not influence the cell's electrochemical behaviour (by optimal placement of the sensors) and that has a barrier that prevents leakage of electrolyte after sensor integration, guaranteeing safety and long cycle life.
- Validated prototype of the battery cell with the integrated (level 1) sensing technologies, scaled up from 1Ah to 5Ah and based on an industrial pilot line.
- Validated prototype of the battery cell (1Ah) with the integrated level 2 sensing technologies.

3. Develop a 24V battery module with a BMS using these cells with integrated sensors

The battery cells with integrated (level 1) sensors will be used for the third (sub-)objective, which is to develop a 24V battery module with integrated sensors. The module structure and BMS will be developed by IKE, FHG, FM, TUE NXP, ABEE and VAR.

The targeted advances and key results are:

- A complete battery module based on six 5Ah prototype pouch cells connected in series, with integrated level 1 sensors connected to the multicell monitoring IC and slave BMS.
- Integration of level 1 sensor analytics with existing BMS concepts resulting in advanced sensor fusion concepts beyond the state of the art.
- Master BMS connected to the slave BMS and programmed with advanced state estimation algorithms.
- Design better chips for the future.

4. Use the new sensing data to create and model improved state estimation functions, provide novel insights for current and future battery chemistry developments and optimise 1st and 2nd life usage

By making use of the data from the internal sensing technologies, robust and advanced state estimation functions will be developed, the fourth (sub-)objective. Several state (SOC/SOH/SOE/SOP) estimation algorithms will be improved, better forecasting algorithms and novel safety concepts (SOS) will be created. This will result in:

- Faster charge protocols can be developed based on temperature and pressure measurements inside the cell.
- Safety limits are more accurately measured and understood leading to safer battery operation (SOS) and use of full battery capacity.
- Using a combination of level 1 and 2 sensor data, control loops can take into account complex interactions between internal (e.g. quality) and external (e.g. outside temperature, cycling behaviour) factors effecting battery health.
- Better battery maintenance with the improved ability to detect, repair or replace defective cell components.
- Increasing the battery lifetime with at least 25% using detailed data (analysis) and more sophisticated lifetime prediction models allowing for improved preventive maintenance measurements to prolong its lifetime.



5. Analyse the cost-benefits of the sensing technologies and the applicability into cell manufacturing practices

ABEE, VAR, FM, IKE, NXP and AIT will implement and exploit the project results:

- Scalability of sensing technology production and manufacturability of cells and modules with sensors.
- Assessment of the minimum required number and type of sensors (per cell/module) to reach desired accuracy/functionality and industrial applicability of sensing technologies.
- Costs benefit assessment of the sensing technologies when implemented in industrial module manufacturing practices.
- Assessment of the recyclability and recycling efficiency of cells, sensors, and modules.

5.1.2 Intellectual property management / Patents and Protection

The background and foreground IP for the KERs will be described within the exploitation process (see Exploitation methodology, point 2e). This will also include a Joint-ownership management (see Exploitation methodology, point 2g). To ensure all partners agree and are aware on the IP ownership situation, a Table will be established to outline the partners' expectations regarding IP ownership. This will be actively maintained and updated during the project to minimize the possibility of misunderstanding and disagreement between partners.

The preparation of patents and protections, will follow the following routine:

- Announcement of a patentable result by description of a KER in the frame of the exploitation plan (2a).
- Following the routine of the KER description (2b-2i), with special attention on Background/Foreground Knowledge Analysis (2e) and Joint-ownership management (2g).
- Proposal for the optimal protection of identified IP results in the frame of Intellectual Property management (2h).
- Following the patenting rules according to the CA.

The Exploitation Manager will update the consortium on the Intellectual property management, Patent and Protection situation of results in a timely manner.



6 Risks

No risks are identified at this stage.



7 Discussion and Conclusions

The first draft of the dissemination and exploitation plan was already drafted in the proposal phase.

Project dissemination is a continuous process, that will follow the whole project and will also continue after the project closure. The dissemination activities will be continuously updated by POL in the excel tables in METT repository and reported to the European Commission.

The methodology of the exploitation plan is reported in this document. According to this plan, a first definition of KERs will be performed in the frame of a workshop within the 1-year GA-meeting. This workshop will result in the first version of an exploitation report, which will be continuously updated to the end of the project. This report will build the basis for the discussion of the exploitation status at the AB meetings (month 18 / D6.4 and month 36 / D6.5).



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Project partners

| # | PARTICIPANT SHORT NAME | PARTNER ORGANISATION NAME | COUNTRY |
|----|------------------------|---|-----------------|
| 1 | IKE | IKERLAN S. COOP. | Spain |
| 2 | BDM | BEDIMENSIONAL SPA | Italy |
| 3 | POL | POLITECNICO DI TORINO | Italy |
| 4 | FHG | FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V. | Germany |
| 5 | FM | FLANDERS MAKE VZW | Belgium |
| 6 | TUE | TECHNISCHE UNIVERSITEIT EINDHOVEN | The Netherlands |
| 7 | NXP NL | NXP SEMICONDUCTORS NETHERLANDS BV | The Netherlands |
| 8 | NXP FR | NXP SEMICONDUCTORS FRANCE SAS | France |
| 9 | ABEE | AVESTA BATTERY & ENERGY ENGINEERING | Belgium |
| 10 | VAR | VARTA MICRO INNOVATION GMBH | Germany |
| 11 | AIT | AIT AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH | Austria |
| 12 | UNR | UNIRESEARCH BV | The Netherlands |

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