4th Issue
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# NEWS

Sintbat

## Silicon based materials and new processing technologies for improved lithium-ion

improved lithium-ion batteries

## In this Issue



# Introduction

According to the European Energy Storage Technology Development Roadmap towards 2030 (EASE/EERA) energy storage will be of the greatest importance for the European climate energy objectives.

The Sintbat project aims at the development of a cheap energy efficient and effectively maintenance free lithium-ion based energy storage system offering in-service time of 20 to 25 years. Sintbat will use innovate approaches to address these aims. These include, the latest generation of anode materials based on silicon as well as a prelithiation process for lifetime enhancement will be implemented in the cell manufacturing process. Insights gained from advanced in-situ and in-operando analysis methods will be used for multi scale modelling targeting on the simulation of aging mechanisms for a reliable life-time prediction and enhancement.

The implementation of high energy materials combined with a low cost and environmental benign aqueous cathode manufacturing process will lead to remarkable cell costs reduction down to 130 € per kWh.

This will enable battery based storage system for an economic reasonable price of less than 400 € per kWh (CAPEX) and will lower the OPEX down to less than 0.09 € per stored kWh for the targeted in-service time of 20 to 25 years (10,000 cycles).

The technical developments will be supported by the set-up of a relevant roadmap as well as a catalogue for good practice. To guarantee the highest possible impact for the European economy the Sinbat consortium installed an Industrial Advisory Board including various European battery material suppliers, cell manufacturer and end-users whereby the whole value added chain in this way is completed within the Sintbat project.

This strong interaction of the Sintbat consortium with relevant stakeholders in the European energy economy will assure that battery based energy storage systems are becoming an economic self-sustaining technology.

# Project Progress

The Sintbat project approaches the half-way mark and is in full swing. We are glad to give you a brief outline of the recent findings in this newsletter.

## Project Management (WP 1):

The first periodic progress report has been completed in time and submitted to the EC. For the preparation of the periodic report (technical as well as financial report after 18 month) active contributary work was provided. The project is on schedule.

## Research and Development:

The main focus of the Sintbat project is to develop and implement advanced functional materials which will include silicon composite electrodes, prelithiated negative electrodes, aqueous processed positive electrodes and a 3D negative current collector into a lithium-ion battery.

## Cell Benchmark, Advanced Electrode Development and Balancing (WP 2):

Commercial available cells that potentially contain Si were scouted and identified. Although the cells have the same cylindrical 18650-format, they differ in chemistry and thus in nominal capacity, voltage, weight and in the end energy density. In order to compare the cells, different cycling tests were performed. Based on these results, a benchmark cell was selected.

<u>Silicon based negative electrode on 3D current collectors</u>

For risk minimisation, two different approaches were chosen. Silicon-based electrodes with low silicon content, and electrodes containing only silicon or silicon composite as active material with higher capacities.

The lower silicon con-tent should help to reach the proposed cycle life. Whereas electrodes with a higher capacity are a requirement to evaluate high prelith-iation levels (> 50%) to achieve long lifetime and energy density at cell level > 260Wh/kg.

The low silicon content Generation-1A cell shows even a better cycling behaviour than the commercial benchmark cell. There has still work to be done to improve the long-term capacity fading of these cells to achieve a comparable cycling stability over 300 cycles.

Generation-1B is a high specific capacity anode, with more silicon than Gen-1A to reduce the electrode thickness at 55 µm.

Figure: Coating machine used at CEA-Liten for Gen-1B formulation selection.

The same silicon material has been used to be able to compare the different approaches. All the electrodes have been coated in dry room using coating machine with a comma bar system Gen-1B was finally evaluated versus reference cathode electrode and compared to

# Project Progress

reference cells containing Gen-1A. It confirms that higher silicon content leads to lower capacity retention. However, 70% of the capacity is retained after 300 cycles. A number of cells have been provided to WP3.

Generation 2A are silicon containing anodes with higher silicon content than Gen1A electrodes, 8 - 15 % thinner than state of the art graphite electrodes with the same loading (in mAh/cm²) coated on a 3D cur-rent collector.

The traditional architecture of battery electrode materials on flat metal current collectors can lead to problems by use of higher mass loadings. This can be related to complexities such as delamination of electrode material from the flat metal foil, the difficulty of electrolyte penetration through a thick electrode or higher resistivity due to long electron paths to the current collector. One possibility to overcome these problems could be the use of 3D current collectors. Two different types of 3D current collectors, a copper metalized polymer non-woven and an expanded copper metal foil, are being evaluated. For electrochemical testing, lab scale electrodes were prepared by use of a slurry-technique. In a next step, slurries with higher viscosity will be examined.

<u>Prelithiation levels evaluation</u>

Also here, two different approaches will be used for prelithiation. Different prelithiation levels (from 10 - 20 %) and reversible capacities (<1,000 mAh/g) will be evaluated in single layer pouch cells (around 25 mAh). Furthermore, different high prelithiation levels (from 50 % to 66 %) and reversible capacities (>1,200 mAh/g) will also be evaluated in Li-ion pouch cells.

To prelithiate electrodes, different prelithiation methods were tested and applied on the surface of pre-fabricated anode sheet with no need to change the existing anode fabrication process. The fabricated electrodes are investigated and the final selection will start soon.

<u>Aqueous processed positive electrode</u>

An aqueus process poses corrosion issues with an aluminum current collector as corrosion reaction happens during the coating step. In collaboration with a member of the industrial advisory board, a current collector with carbon coating has been proposed for investigation. Current collector protection is known to be one the best solutions to mitigate Al corrosion during NMC electrode coating and drying. Finally a grade was selected and produced. This collector will be used to continue the optimization of Gen-2 cathode formulation and manufacture the final electrode to be used in prismatic prototypes.

### Aging Mechanisms and Tailoring of Electrolytes (WP3):

To optimise the longvity of batteries means a thorough understanding of the aging mechanisms‘. Accordingly, the silicon based materials were subject to a in-depth examination.

The morphological characterization was done by Scanning Electron Microscopy, EDX and FIB-SEM nano-tomography, the Crystalline structure by lab XRD.

New insights on nanoscale were gained by applying Small Angle X-ray Scattering (SAXS) and Small Angle Neutron Scattering (SANS).

# Project Progress

The SAXS measurements on the cycled electrodes (post-mortem experiments) enabled the comparison of the Si-based electrode microstructures in its pristine condition and after different number of cycles. In conclusion, SAXS and SANS techniques are suited for the characterization of nanoscale electrode organizations and are capable of detecting morphology modifications after cycling of the electrode (in the lithiated state). These exsitu results show that in-operando SAXS and SANS are extremely interesting techniques for probing in real-time the effects of lithiation/delithiation on the composite anodes nanostructure.

Besides the chemical/structural characterization by NMR efforts were made to study the evolution of the Solid Electrolyte Interphase (SEI) on advanced silicon-based electrodes during cycling in liquid and solid electrolyte cells using hard X-ray photoelectron spectroscopy (HAXPES) at the BESSY II Synchrotron facility. Further work is dedicated to determine the electrochemical parameters of Si-based anodes in Li-ion batteries using galvanostatic and cyclic voltammetry test.

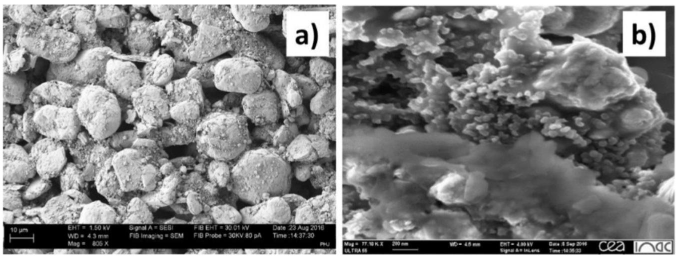


Figure: SEM images of the pristine Gen-1A negative electrode at two different resolutions.

Development of electrolyte in litre-scale batches

Liquid electrolytes: Being an essential component in a rechargeable Li-ion battery, today's state-of-the-art Li-ion battery electrolytes are composed of LiPF6 as the Li salt, low-molecular-weight carbonates such as ethylene carbonate (EC) and ethyl methyl carbonate (EMC) as the solvents, and various additives in small amounts. LiPF6 still holds the dominating position as the salt for conventional non-aqueous electrolytes due to its very well-balanced properties. With our current knowledge, we suggest the baseline electrolyte for silicon anodes in this project to be LiPF6 in EC/EMC with the addition of FEC as an additive. Further optimization in the choice of salt, solvent and novel additives will be carried out to improve the performance of the silicon-based batteries within this project.

Solid polymer electrolytes: As outlined in the Sintbat project grant agreement, one strategy to stabilize the interface between electrode and electrolyte is to utilize mechanically flexible solid polymer electrolytes (SPEs) in place of the traditional liquid electrolytes. Here, new polymer host materials have been investigated that are alternatives to the traditional polyethers that are well-established but insufficient in terms of performance. A new electrolyte material based on a copolymer of ε-caprolactone and trimethylene carbonate – a polyester/polycarbonate – was recently developed that, at the right composition of its constituents, constitutes some improvement over existing materials in terms of battery-relevant performance metrics such as ionic conductivity and

# Project Progress

cation transference number. This electrolyte materials have been initially tested vs. silicon as a negative electrode material in a flexible battery cell construct in half-cell and full-cell setups showing excellent cyclability with high capacity retention over at least 100 cycles.

With this electrolyte materials platform as a starting point, we have developed new polymer architectures that incorporate ion-conducting building blocks but add other functionalities in order to improve such properties as the mechanical strength and high-temperature stability. The specimen suffer from limited capacity utilization that can be rationalized by the high polarization between charge and discharge as a consequence of limited ionic conductivity of the material at the operational temperature. Ongoing work to rectify this will require a combination of improving the ionic conductivity of the SPE, tuning its mechanical properties, optimizing the electrode formulation and revising the cycling scheme.

### Modelling, Simulation and experimental validation (WP4):

Structural and morphological testing of components

Within this task we used X-ray computed Tomography (XCT) for the characterisation of the pristine (non-cycled) electrode material. In addition to the XCT results, we analysed in collaboration with CEA (from WP3) FIB-Tomography results. This collaboration highlights also the link of different work packages within the project. The combination of XCT and FIB-Tomography bridges the µm- with the nm-scale. The analysed data from the 3D reconstruction is then delivered to Universitiy of Warwick and used for the simulations. Once the relevant samples were measured, we developed and tested the analysis algorithm for the segmentation of the different phases. We obtained reconstructed XCT data, which gave volume data files containing the 3D information of the sample. Due to the complex material composition in the electrode system, conventional approaches regarding the segmentation of the different phases are not applicable. For the analysis, we developed the so called constrained threshold interval variation algorithm. Before the segmentation is applied we perform preproces-sing by modifying the histograms.

Rapid cell ageing testing and characterisation

A rapid aging procedure has been developed in order to predict the long-term cycle-life of silicon anode. The method is based on galvanostatic charge-discharge tests conducted at elevated temperatures and current rates. The capacity fade of the Si-based electrode is dependent on these parameters - higher current density and temperature should result in decrease in capacity retention. Various current rates and temperatures were applied  in order to evaluate the influence of those parameters on aging rate. The electrochemical properties of cells (specific capacity, capacity retention, Coulombic efficiency) examined at various conditions were being determined.

Open circuit potential measurement performed before cycling showed no dependences with storage temperature. Measured specific capacity decrease very fast in elevated temper-

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in elevated temperature was related to lithium dendrite formation at the counter electrode.

Dendrite formation cause fast electrolyte degradation and possibly small internal shortcuts in the cell. This assumption is based on the cycle efficiency parameter analysis, which at some cycle show rapid drop. Different current loading of the cells resulted in similar behaviour for 0.05-0.2 C, and a fast capacity drop at 0.4 C. This result is generated by large electrode thickness, which cause over-potential generation at high current flow. The over-potential generation is the reason for reaching the quicker cut-off voltage and sub-sequently a lower discharge capacity.

Development of a 1D macro electrochemical cell model

Phenomenological-based electrochemical models for Li-ion batteries exhibit an accurate prediction of its voltage response. These models include Partial Algebraic Nonlinear Differential Equations (PADEs), the parameters of which are commonly fitted according to typical cycling electrochemical experiments. However, currently these models do not account for the features which are prevalent in Silicon-based anodes, namely, dynamics where diffusion is not a dominant factor, volume expansion and its effect on the growth mechanisms of the Solid Electrolyte Interface (SEI). Thus, a model including these particular characteristics is necessary to achieve an accurate long-term prediction of the voltage response (capacity fade), for a lithium-ion battery including silicon as a key component.

The initial modelling task has been focused on developing a Single Particle Model (SPM) for the full lithium-ion battery system. In contrast with the standard SPM, the model developed includes two salient features: (A) The effect of the Electrolyte Transport Dynamic, the over-potential of which cannot be neglected for currents above 0.5C. (B) The large expansion of the volume in Silicon particles, which is the main difference with respect to graphite-based anodes.

The simplicity of this approach, namely, the dynamic of one particle represents the behaviour of a whole electrode, enables the applied battery current to be directly related to the particle surface. This leads to an easier interpretation of the particle behaviour with respect to the voltage response. The model will be refined in the future.

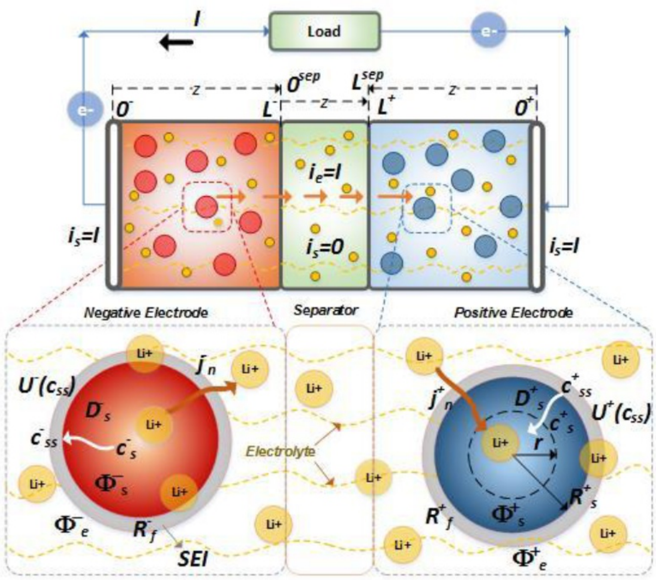


Figure: Schematic of the Single Particle Model.

# Project Progress

Development of 3D microscale FE models to predict the in-situ and macroscopic mechanical response of the anode

Non-linear micromechanical chemo-mechanical 3D Finite Element (FE) models are able to predict in-situ and macroscopic mechanical response of the anode during lithiation and delithiation cycles and can be linked with electrochemical models to predict the capacity fade. The development of such models is the main objective of this task. These models consist of a combination of anode microstructure reconstruction tools, a constitutive model of a coupled chemo-mechanical behaviour of anode constituents and the computational homogenisation framework.

In this phase of the project, the work has been focussed on two aspects:

(1) the reconstruction of the anode microstructure based on the experimental data from Materials Center Leoben and

(2) the chemo-mechanical model for a stress-assisted lithiation of Si particles.

## Implementation, Cell Development, Analysis and Safety Tests (WP5):

In this work package advanced materials will be brought into automatized production process. This needs to be stepwise from lab scale to mini-plant production for larger amounts (material, production processes, cells). In a first step, a double-side-coated anode, with a higher silicon content was produced in cooperation by VARTA Microbattery and VARTA Micro Innovation. Those electrodes were cut and in sample shop cells were built. Because the electrodes were finally implemented in CoinPower-cells against an industrial standard cathode, a higher mass loading of 2.9 mAh/cm$^2$ was realized.

This process is at this stage a manual process. Basic indicator for cell performance is behaviour during cycling. Main criterion is: achievable number of cycles until capacity is fallen below a predefined minimum value. For a successful market entry, a silicon based cell should provide a higher initial capacity at beginning of life compared to a State-of-the-Art commercial cell.

Next steps will be:

• cell build with modified electrode setup (influence diameter jelly roll/less compression at calendaring)

• processing electrodes with different amount of Si-base active material

• different type/thickness of foils as anode and cathode collector foil

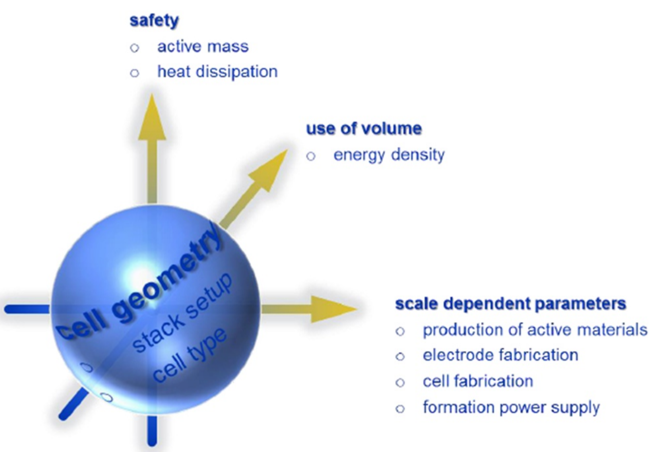


Figure: Correlation of aspects in development projects based on novel materials.

# improved lithium-ion batteries

# Project Progress

## Life Cycle and Health Risk Assessment (WP 7):

The LCA according to ISO EN 14040/44 is ment to provide decision support for the product design towards the most most environmentally benign concepts. Therefore reducing the environmental impacts to a minimum (s. figure).

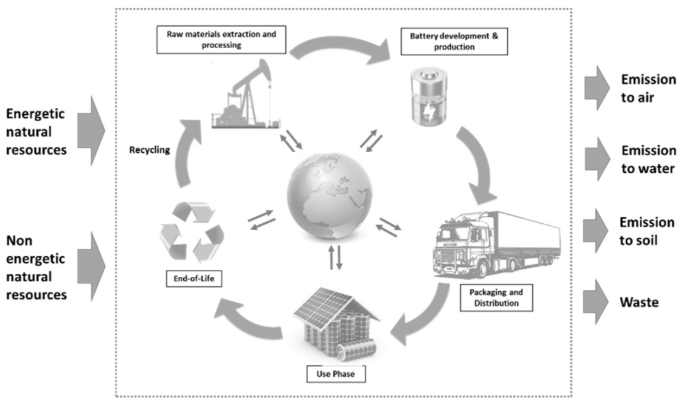


Figure: Showing all life cycle phases of the battery including the energy and material flows as well as emissions.

As a first step, an appropriate reference model was developed which reflects commercial batteries. It was modelled using the software GaBi and the database Ecoinvent.

The results allowed:

• The agreement on first definitions, settings, functional unit and system boundaries for the LCA studies planned within the Sintbat project with all partners;

• The set-up and evaluation of material and energy flows and corresponding environmental impacts over the full life cycle for the reference systems;

• Insights into the impact of single modules or life cycle steps on the overall environmental balance.

For this, the battery cells 18650 with a life time of approx. 8000 cycles have been selected. Further assumptions for the LCA model can be found in the following table.

| Establishment of an appropriate reference model | | |
|---|---|---|
| **Energy storage:** | • Battery type: | 18650 battery cells |
| | • Life time: | ca. 8 000 cycles |
| | • Energy storage: | VARTA puls 6 |
| **Use phase:** | • Application: | private consumption |
| | • Scenario: | 180 m² one family house |
| | • Electricity demand: | 4500 kWh / year |
| | • Energy saving: | 3095 kWh / year |
| | • Location: | Ellwangen |
| **Life time:** | 25 years | |
| **Data source:** | • VARTA | |
| | • Ecoinvent database v3.3 | |

Table: Overview of the first LCA assessment for the reference.

An essential but time intensive part of the LCA is the Life Cycle Inventory (LCI) of all material and energy flows along the full life cycle of a product or process. Consequently, the data gathering process started early in the project. The LCI for the reference modules was prepared based on data sets available in the Ecoinvent database, literature and specific data from the industrial project partners.

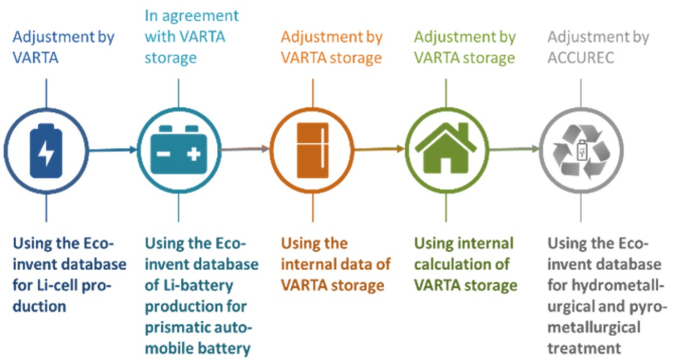


Figure: Overview of the different life cycle phase of the battery and the involved project partners.

# Project Progress

The next essential steps of work in WP 7 will be the continuation of the data gathering in order to set-up a project internal LCI database and to modulate the first LCA for the reference model.

Dissemination, Exploitation and Business Plan (WP 8):

The third project newsletter has been sent to a broad field of potential interested parties. In the past months, Sintbat has been presented to a wide scientific and industrial public on several events throughout Europe, e.g. 4th Energy Symposium, Aachen; M&M Microscopy & Microanalysis, St. Louis/USA; 6th Polish Forum Smart Energy Conversion and Storage, Bukowina Tatrzanska /Poland; 4th Energy Materials Symposium, Bath/UK.

In creating a Business Model a market analysis is needed. The first step was to define the con-crete object of further investigation by means of an application tree.

For stationary applications the battery pack and systems level were chosen for further investigation and for mobile application the small coin cells as well as the cylindrical/ prismatic cells. The manifold applications were prioritized afterwards.

Subsequently the regi-ons/countries of interest were determined being in Europe the countries Germany, France, UK, Italy, Spain and Overseas the US, Australia and India. These countries are par-ticularly suited because of factors such as market size & development forecast, lower market entry barriers etc.

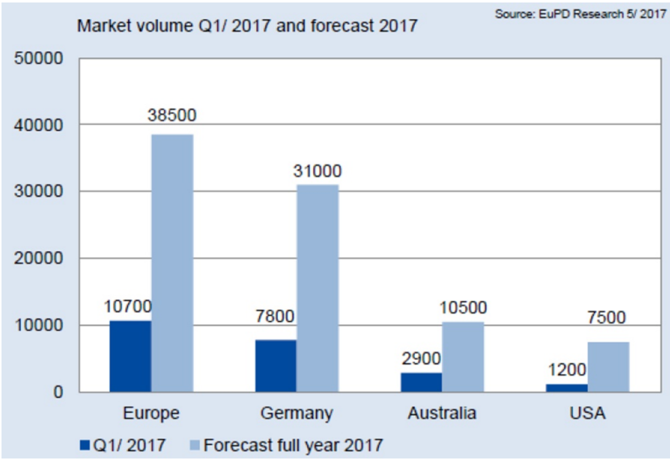


Figure: Market volume and forecast 2017.

For further information gathering secondary sources such as market studies are analysed for relevant information. For primary sources, questionnaires were developed.

The first sur-vey was conducted among the participants of the 4th Energy Symposium in October 2017 and on a broader scale thereafter.

# General Assembly Meeting

Date: 10th-11th October 2017 Location: Ellwangen, Germany

For the third General assembly meeting of Sintbat, all partners were welcomed by Varta Microbattery and EurA as both project partners have their headquarters in Ellwangen, Germany. From the 10th - 11th of October 2017, the latest progress of the project was presented and discussed in detail.

The meeting started right away with the scientific work packages and presentations of the main issues that occurred during the past half year. In the morning session the work results concerning advanced electrode development and balancing, aging mechanisms' and tailoring of electrolytes as well as modelling and simulation were presented and a lively debate commenced.

In the afternoon the progress of cell development with issues of up-scaling of the electrode manufacturing from lab scale to semi industrial as well as different aspects of dissemination, exploitation and business plan. The partners were provided with interesting information how the life cycle analysis is conducted and which data are queried.

At the beginning of the second meeting day matters regarding the Project Management were presented, particularly on the preparation of the project 18month report. The focus however lay on the EC innovation radar, an European Commission initiative to identify high potential innovations and innovators in EU-funded research and innovation projects. The hosts and all project partners were proud to welcome Ms. Deborah Creamer as the EC-Expert Evaluator and competent contact person. Several potential innovations and the way of exploitation on the timescale were identified.


Afterwards, all participants were glad for the opportunity to visit the Varta Microbattery production where an impressive, "very lean" production and packaging of the world's leading coin cell producer could be seen in detail.

It was decided that the next general assembly will take place on the 17th - 19th April 2018 in Warsaw. The meeting was then concluded with a very positive feedback and outlook as all partners are getting excited for the next time period and the things to come.

# Newsflash

## E-car boom: demand for lithium has increased enormously

The expected e-car boom is creating an increasing demand for lithium, which is necessary for the batteries. In the coming years, almost all major carmakers in the field of electromobility want to expand significantly.

For example, Ford announced recently that it would spend a total of $ 11 billion on developing and building e-cars by 2022. Not least because Tesla has created an increasing demand.

Source: DERA

According to the study "raw material evaluation - lithium" of the German Mineral Resources Agency

(https://www.deutsche-rohstoffagentur.de/DERA/DE/Downloads/Studie_lithium_2017.pdf?__blob=publicationFile&v=2)

the need is secured until 2025. But that is only possible because the major mining countries such as Australia, Chile and Argentina want to expand their production vigorously. New entrants such as Canada and Mexico are building capacity.

The additional lithium demand for electric cars alone is estimated at 3.5 times the current lithium production by 2035, which is 33,000 tonnes, according to the Dera study.

A doubling of demand for the raw material is expected by 2025. Then the worldwide available lithium supply should have risen to 110,000 tons. The demand has also led to a sharp increase in the price of lithium carbonate - from $ 6,500 to $ 15,000 per ton in just two years.

A few weeks ago, the Federation of German Industry had warned of a massive shortage of raw materials in Germany. In addition to lithium, cobalt and graphite are required to a greater extent.

However, especially in the case of the latter two, the situation is critical, as 60 percent of the cobalt needed worldwide comes from the Congo, 70 percent of the graphite comes from China.

# Newsflash

## Energy Innovation Europe Network

Energy Innovation Europe

With the use of renewable energy sources, Europe has decided to obtain and use energy in a sustainable, resources saving, and $CO_2$ neutral manner.

To achieve this goal in the long-term, innovative technologies that harvest energy from renewable resources, decrease energy consumption, enable an efficient conversion, and deliver energy on demand via novel energy storage facilities have to be developed.

These technical challenges can be managed fast and most effectively by the collaboration of companies and industry experts from across Europe. To facilitate these joined activities EurA AG founded in 2017 the Energy Innovation Europe (EIE) network.

This network connects experts from the entire energy value chain, supports the acquisition of funding on national and European level and establishes contact to political decision makers.

Current key aspects of network activities are:

- Fuel Cells & Hydrogen for mobile & stationary applications
- Geothermal & Hydro Power components & plant development
- Energy Efficiency in buildings & production processes
- Renewable Energy production & storage
- Network Technology & Distribution components and communication (ICT)
- E-mobility

The EIE network will grow further in 2018 and is open to new partners.

Sintbat was presented to over 60 international participants in the 4th EnergySymposium organized by the EIE, where a first market survey was also conducted for the Sinbat project.


# Event Watch

September is a strong month for events which are strung like pearls on a chain:

**Energy Storage Europe Expo and conference**
03.03. - 15.03.2018    Düsseldorf, Germany

**Solarcon China 2018**
14.03. - 16.03.2018    Shanghai, China

**Globalcon**
Energy, Power & Facility Management Strategies
21.03. - 22.03.2018    Boston, USA

**ESC Energy Storage China / CEEC – Clean Energy Expo China**
27.03. - 29.03.2018    Peking China

**Battery Day NRW**
09.04. - 11.04.2018    Münster, Germany

**Hannover Messe 2018**
Integrated Energy Leading Trade Show for Integrated Energy Systems and Mobility
23.04. - 27.04.2018    Hannover, Germany

**The smarter E Europe**
Intersolar Europe / ees europe / EM Power / Power2Drive Europe
20.06. - 22.06.2018    Munich, Germany

**Intersolar North America / ees North America**
international exhibition for solar, batteries and energy storage systems
10.07. - 12.07.2018    San Francisco, USA

**CNIBF – China Shanghai Int. Lithium Battery Industry Fair**
23.08. - 25.08.2018    Shanghai, China

**MCE Asia – MOSTRA CONVEGNO EXPOCOMFORT ASIA**
The leading trade exhibition dedicated to energy efficient solutions for the Cooling, Energy, Water and Heating sectors oft he built environment
05.09. - 07.09.2018    Singapur, Singapur

**Hydrogen + Fuel Cells North America / SPI Solar Power International**
24.09. - 27.09.2018    Anaheim, USA

# Consortium

### VARTA Microbattery GmbH

VARTA Microbattery (VMB) is an internationally leading and globally active manufacturer of retail and OEM batteries and has been operating for more than 125 years. VMB employs nearly 750 persons in Germany and approx. 2,000 worldwide. The company headquarter is located in Ellwangen in the southern part of Germany where the entire research, engineering and production of the electrochemical cells are done. 150 VARTA employees work in the Innovation Tower at our headquarters in Ellwangen.
This central Research and Development department focuses on developing new products and optimizing existing solutions. Particular attention is paid to material and structural research, converting and storing energy (light, heat, vibration, etc.), and nanotechnologies, fuel cells, and printed batteries.

### Uppsala Universitet

Uppsala Universitet (UU), founded in 1477, is the oldest University in the Nordic countries. In all different ranking lists UU is among the top 100 universities in the world. Today, it trains more than 43,000 students, and employs 6,000 people. There are about 2,500 active graduate students; 44% of these are women. Each year, the University awards some 270 doctoral degrees.
The Ångstrom Advanced Battery Centre (ÅABC) is an integral part of the Department of Chemistry – Ångström Laboratory, Uppsala University; it is housed within the Ångström Laboratory – one of Europe's best equipped Materials Research Laboratories. The Centre involves the full-time activities of 35-40 researchers, of whom 8 are Senior Staff and research engineers; the remainders are PhD students and postdocs. It is the leading basic research environments for the development of electrochemical storage materials and advanced battery technology in the Nordic countries. It is publishing more than 20 battery research papers per year. It is a member of ALISTORE-ERI a network of excellence for battery research started more than 10 years ago within FP6. It is a member of SHC (The Swedish Hybrid Vehicle Centre) and of several existing and former FP7 programs.

# Consortium

### Varta Storage GmbH

VARTA Storage

The VARTA Storage GmbH (VS) is a developer and manufacturer of stationary battery storage systems. The company has substantial know-how in the field of energy storage by using long-life lithium-ion batteries and conducts in the context of innovative research and development activities. The first commercial product from VARTA Storage is the ENGION Family, a modular storage system which allows the storage of PV-Energy in order to increase the self-consumption of private households up to 70%. With the development of novel large-sized storage systems the company addresses new applications like the efficient use of renewable energies and the support of grid stability.

### Commissariat à l'énergie atomique et aux énergies alternatives

CEA is a French government-funded technological research organization. With more than 15,000 researchers and co-workers, its activities cover four main areas: Energy, Defence & security, Health & information technologies, and Fundamental research. Two Institutes from CEA both located on the CEA Grenoble centre are involved in the Sintbat project. CEA-INAC is a fundamental research institute (420 people) involved in nanoscience, while CEA-LITEN is a technological research institute (1,000 people) specialized on energy R&D (fuel cell, batteries, biomass, and solar application).
CEA-INAC develops expertise in advanced characterization on the Nanocharacterisation platform, a large facility devoted to up-to-date electron microscopy, spectroscopy and NMR on the Minatec campus of Grenoble. INAC also manages X-rays beam line at ESRF facility and ILL neutron reactor. For many years, CEA-INAC has developed strong knowledge in LIB investigation and in particular for Si based electrodes. The Nanocharacterisation facility not only provides access to high tech equipment with experienced staff, but also develops new characterisation methods to add to its portfolio.
The Laboratory for Innovation in New Energy Technologies and Nanomaterials (CEA-LITEN) has a unit dedicated to energy for transport application (Department of Electricity, Hydrogen and Transport, DEHT) which has more than 15 years experiences in new materials for Li-ion batteries. Today, this entity is equipped with a dry room of 300 $m^2$ dedicated to Li-ion batteries prototyping from the electrode material up to the cell and more than 600 $m^2$ dedicated to Li-ion module and pack system development. CEA-LITEN intellectual properties portfolio on Li-ion batteries is more than 100 on the topics of material synthesis, battery architecture, and BMS.

# Consortium

### WMG, University of Warwick

WARWICK
THE UNIVERSITY OF WARWICK

The University of Warwick is one of the UK's great success stories. In less than fifty years since being founded the University has become one of the UK's best universities, consistently at the top of UK league tables and rapidly climbing the international league tables of world class universities. Warwick is globally connected, forward-looking and entrepreneurial. At its heart Warwick is about creating new ways of thinking and achieving: making us stand out from our competitors and the more 'traditional universities' and creating an inspiring place to study and undertake research.

As one of the largest academic departments at the University, WMG is able to make a real impact on industry through collaborative R&D and top class education. UK government reviews have cited WMG as an international role model for university and business collaboration. What makes it unique is a multidisciplinary approach to innovation; pushing the boundaries for science and technology and enabling the transfer of knowledge into new areas. Working at the forefront of emerging technologies, and across diverse projects and industry sectors, WMG tackles real world challenges in an environment that inspires confidence and creativity.

### MCL Leoben

MCL MATERIALS CENTER LEOBEN

The Materials Center Leoben Forschung GmbH (MCL) is the leading Austrian institution in the field of applied materials science with around 150 employees. In particular, it is operating the Comet K2 Center on Integrated Research in Materials, Processing and Product Engineering (MPPE) which is the largest competence center in the field of research on application of materials in Austria. The research focuses on Integrated research in materials, processing and product engineering and covers the entire supply chain from material synthesis via materials processing and manufacturing and is also including the behavior of components in service till their deployment. About 50 scientific institutions and about 90 companies are collaborating in this network on material based innovations in the fields of (a) new materials and novel material solutions for future applications like energy storage and harvesting, (b) new and optimized processes and process chains, (c) new design concepts, (d) innovative material driven products, and (d) reliability of products in service.

The MCL has modern Lab equipment suitable for cutting edge failure characterization and material characterization.

# Consortium

### VARTA Micro Innovation GmbH

VARTA Micro Innovation GmbH (VMI), with registered office in Graz (AUT), is a joint venture between the battery manufacturer VARTA Microbattery (Ellwangen, DE) and Graz University of Technology (AUT). The business purpose of VARTA Micro Innovation GmbH is R&D in the area of electrochemical energy storage systems. Within VARTA Micro Innovation both, the industrial fabrication know how from VARTA Microbattery and the basic research know how from Graz University of Technology for various electrochemical energy storage systems are merged together. This unique configuration enables VARTA Micro Innovation to perform a fast transfer of newly developed technologies into production state. The R&D activities of VMI are divided in three main research areas:

Lithium Power - Improvement of specific energy (Wh*kg-1) and energy density (Wh*l-1)
Heat Power – Enlargement of the temperature operation range
Rapid Power – Improvement of the rate capability

VARTA Micro Innovation is highly experienced in research, reverse engineering and ordered analysis in the area of lifetime prediction and reliability of Li-Ion Batteries for different application fields (e.g. EV, storage etc.). VARTA Micro Innovation has also many years of experience in working with high capacity negative electrode materials for lithium ion batteries. This work includes on the one hand basic research of high capacity electrode materials as well as electrode fabrication and construction of batteries with these materials on prototype level.

### EurA AG

EurA AG has been established in 1999. As an innovation service provider, EurA advises more than 800 mainly medium-sized companies in Germany, covering all industrial sectors. EurA mainly focuses on consulting and assisting companies in national and European R&D projects. This comprises the entire innovation process, including the generation of promising ideas, the search for suitable partners, the establishment of the project consortium, the technical and administrative coordination of the project as well as the project controlling.

# Consortium

### Uniwersytet Warszawski

UNIWERSYTET WARSZAWSKI

University of Warsaw (UW) was founded in 1816. The University brings together scholars from a variety of disciplines. It is the place of a diversity of scientific research. Nearly 60,000 people study at the University of Warsaw every year. The candidates are offered a very broad range of courses in the fields of humanities, social sciences and natural sciences, as well as many interdisciplinary courses combining knowledge and skills of many disciplines. The University offers undergraduate and doctoral studies, organizes summer schools, postgraduate studies and vocational courses, initiates interdisciplinary programmes and introduces new teaching techniques.
The Faculty of Chemistry, University of Warsaw, is a large research and teaching centre. There are fully developed programs in analytical chemistry, biochemistry, inorganic, nuclear, organic, and physical chemistry as well as in chemical physics. The faculty has been regarded as one of the top chemistry departments in the country for decades, and it attracts outstanding faculty and students. Many faculty members have distinguished themselves both nationally and internationally.

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