The Battery Experts Forum: Europe's largest conference on the topic of Battery Technology

Date: 10.-12. April 2019

Place: Frankfurt am Main Fairgrounds.

(10 pages briefing,
conclusions on page No. 10.)

LECTURES

Over 100 leading users, developers, politicians and researchers from international companies and institutes will be presenting the latest trends about batteries and power sources:
From world market view;
cells & batteries supply chain;
through technologies used and newest developments in this field;
up to safety features of power systems, including all chemical and electronic safety measures;
and future recycling programs, hopefully helping us not go into raw materials shortage problems.

Presentations:

- World Market
- Electric Mobility
- Safety and Life-time
- Battery Production
- Next Gen Materials
- Cell Production
- Battery Management and Components
- Testing and Certification
- Functional Safety and Battery Management
- Standards and Regulations
- Home Storage
- Fire Protection and Safety
- Charging
- Recycling

SPECIALIZED EXHIBITION

Renowned international companies from the battery industry, over entire power value chain, presented new products & developments, technologies and solutions at 80 exhibition stands in the Forum der Messe Frankfurt.
Main sponsors & exhibitors:

- Leading cell manufacturers:

- Panasonic, No.1 World Li-Ion cells Manufacturer, pioneer in high energy cells, enhanced safety and EV power systems (Tesla Gigafactory in Nevada, USA, with planned output 35GWh/year); https://eu.industrial.panasonic.com/products/batteries-energy-products;
- MURATA, www.murata.com
- BYD Co Ltd., www.byd.com

- LG-Chem, total solution provider based on strength material and technical support. With 23 years' of experience in successfully delivering energy solutions to customers in the global market, LG Chem is recognized as the unparalleled industry leader in Lithium-ion battery. LG Chem, which is the leading chemistry-based company among global battery cell manufacturers, has led the world lithium-ion battery market by leveraging its proprietary material technologies.
  Positioned as a global leader in the battery industry for not only IT applications but also in new applications such as Power tools, e-mobility, and Energy Storage Systems (ESS), the company has actively developed new products and secured the battery production capacity as a global player to raise dominance in the next-generation energy market; www.lgchem.com
- SAMSUNG SDI **creative leader in the energy, cutting-edge materials and automotive industries.** Samsung SDI is committed to bringing customers the most creative and sustainable innovative energy-storage products for IT, Power Application, ESS, all kinds of e-mobility as well as electronic materials. We are energy storage and materials solution leader in the global markets and we keep focusing on efforts to drive next generation's growth, www.samsungsdi.com
- EMS Elektro Metall GmbH, Elektro Metall Schwanenmühle is a global company specializing in the production of flexible electrical connections made of copper and aluminum. Through the use of advanced joining and assembly techniques, we can provide our customers in the automotive, wind and battery technology with high quality supply high quality products and assemblies. We support our customers from product design to prototype construction to mass production, www.ems-power.com
- BMZ GmbH, European leader in intelligent Lithium-Ion battery system solutions. As a system provider and specialist for intelligent solutions, BMZ has established a pioneering position in the fast-growing lithium-ion battery market. With 25 years of experience, more than 3,500 customers and about 400 new projects per year, BMZ is a leader in the design and construction of battery systems in Europe. Around 3,000 employees work for the BMZ Group, more than 1,000 of them in Germany. www.bmz-group.com
- ARROW / Analog Devices / TracoPower, A 'Fortune 500' company with 20,100 employees worldwide, Arrow Electronics guides innovation forward for over 200,000 leading technology manufacturers and service providers. With 2018 sales of $30 billion, Arrow develops technology solutions that improve business and daily life, www.arrow.de
- AMBI BOX, offers products (from the component kit to the complete system) and development services for DC-based technologies. The company specializes in the networking of energy components and energy systems through its own hardware (for example **ambiBOX®**) as well as software and cloud solutions (for example **sidOS®**), www.ambibox.de
- Data TEC GmbH is the largest German specialist distributor for oscilloscopes, measuring instruments, power supplies, test equipment and thermal imaging cameras. From its headquarters in Reutlingen, dataTec has been serving well-known industrial companies, craft enterprises, public authorities and educational and research institutions for more than 30 years. In addition, dataTec offers you a unique selection, competent and personal advice as well as a customer-oriented service, www.datatec.de
- MANZ AG, a globally active high-tech supplier of production systems and an important driver of innovation, helping to achieve breakthroughs in key technologies of our times such as displays and devices for global communication needs, sustainable power generation and storage as well as e-mobility, www.manz.com
- TATA Steel, www.tatasteel.com

- AMADA Miyachi, www.amadamiyachi.eu
- DIGATRON, www.digatron.com
- GIGAVAC, www.gigavac.com
- Schott, www.schott.com
- Fraunhofer Institute, www.batterien.fraunhofer.de
- FS Bondtec , www.fsbondtec.at
- AUTOLIV, www.autoliv.com
- AVL, www.avl.com
- TWS, www.tws.com
- DEXERIALS, www.dexerials.jp
- CADEX, www.cadex.com
- ALEX BREUER GmbH, www.alexbreuer.de
- UL Laboratories, www.ul.com
- Solaris e-bus, www.solarisbus.com
- ACM City Taxis (prototype), www.adaptive-city-mobility.de

PRESENTATIONS OVERVIEW

- World Market:
  - The Rechargeable Battery Market, by Christophe Pillot, AVICENNE Développement France. Contents: — The rechargeable battery market in 2018 — Li-ion battery value chain — xEV market in 2018 and forecasts up to 2030 — Advanced Energy Storage for Grid systems & renewable energy — Rechargeable battery market forecasts up to 2030. The main goal of this Presentation is to forecast the worldwide rechargeable battery market from 2018 to 2030 for Electronic devices, Automotive and industrial applications. The presentation mostly focuses on xEV market, Li-Ion battery and components supply chain.
  - The Future of Batteries. Trend, Price, Technology and Main Markets, Sven Bauer, BMZ Group. A passionate battery expert who has been focused on the battery and charging technology for 25 years gives his vison on battery power sources. BMZ GmbH was changing the hobby into a career, quickly developed into a global player in the battery industry, with multiple production locations and sales offices worldwide. BMZ Group is the primary shareholder in TerraE Holding GmbH, whose goal is to develop German cell production by 2020. BMZ is a major driving force in this project thanks to years of experience and strong position in battery systems.
  - World Lithium-ion Battery Market -China Market Analysis, Kevin Wang, Tianjin Lishen Battery Joint Stock Co., Ltd. Presentation is about the world lithium battery market, especially in China. A short outlook about the development of the lithium battery market in China, market competition and the industry risks. As conclusion, brief perspective of the future development.

- Electric Mobility
  - Eurabus e-drive concept for busses & other commercial vehicles, Michael Düde, Eurabus GmbH, Eurabus has developed an outstanding e-drive concept for busses and commercial

vehicles which satisfies the customer with great energy efficiency, superior driving ranges, long life time and an excellent TCO calculation. Eurabus will present the latest battery technology concept for busses at the 16th Battery Experts Forum 2019.

- The freight traffic electrification on Europe's streets, Dr. Daniel Aggeler, E-Force One AG, Especially beside the public transportation the freight traffic contributes to the human an environmental pollution. Within the scope of several model experiments the economical and ecological circumstances in reference to the freight traffic electrification is investigated. (With more than 1 million electrically driven truck kilometres E-Force One AG has a comprehensive data basis available and describes the current and near future challenges to be expected regarding technical and economical challenges of the freight traffic electrification.).
- AI-driven electric vehicle design and failure prediction by real-time monitoring, Dr. Stéphane Foulard, COMPREDICT GmbH, COMPREDICT has developed a software-based solution to assess the usage of each individual car and enable predictive maintenance. No additional sensors or hardware are needed. By combining real-time monitoring and artificial intelligence, COMPREDICT can predict failures of car components like electric motors or batteries.
- The World´s Greenest Battery, Peter Blomquist, Northvolt AB, At Northvolt, sustainability is not a stand-alone strategy or function. It is the core of our competitive advantage and the impact we strive to have. Our mission is to build the world's greenest battery with minimal carbon footprint and highest ambitions for recycling, to enable the European transition to renewable energy.
- LiB cell and material marketing strategy in xEV era, Sachiya Inagaki, Yano Research Institute Ltd. It is expected that the xEV market will grow faster and larger than expected thanks to severe regulations on vehicles emissions. But, can we really expect such high expanding of this market? Can we totally rely on the governmental policies for growing this market? I would like to make some remarks on how we should see this market and how we should make it grow in a healthy way.
- Challenges in the electric 2-wheel sector, Thomas Grübel, GOVECS AG. Perpetually rising petrol prices, global warming and the ever increasing traffic volumes in the inner cities on the one hand, and the high demand for individual mobility on the other hand necessitate smart solutions. This fundamentally new way of thinking about environmentally friendly transport with consumers having the requisite financial means and an increasing awareness for light electric vehicles shows especially for the European market a significant growth potential due to an regulatory „push" towards E-Mobility. This speach by Thomas Grübel outlines next to insights highlighting the underlying trends driving the demand for e-Scooters, the drivers and current as well as tomorrow's challenges of electric vehicle penetration and the implications for all stakeholders in the electric 2-wheel sector

- Safety and Life-time:
  - BattHEALTH - Battery Life Cycle Tracking, Manfred Przybilla, Ambibox GmbH, BattHealth is a battery tracing tool which calculates the aging of Li-Ion batteries used in mobile and stationary applications. The core of the technology is the collecting of battery data in combination with testing of batteries after its usage. BattHealth creates a digital twin and uses artificial intelligence for computing customer specific battery parameters.

- Battery Safety, by Shmuel De-Leon, Shmuel De-Leon Energy, Ltd. Contents: —Safety hazards —Safety guidelines —Safety equipment —Safety Design —Safety disposal —Safety standards and testing.
- Thermal runaway initiation and propagation in Li-ion batteries, Dr. Andreas Pfrang, European Commission - DG Joint Research Centre, Thermal runaway propagation tests of Li-ion batteries can provide important information for avoiding safety-critical situations. An overview of thermal runaway initiation methods as well as an overview of current standards related to thermal propagation testing will be given. Further a thermal runaway model based on thermal data of battery materials will be presented.
- Safety Aspects of Lithium-Ion Batteries, Dr. Michael Abert, Fraunhofer-Institut für Chemische Technologie ICT, Failure of Lithium ion batteries with their high energy content can lead to severe consequences. Abuse tests give an insight into the safety behavior of recent batteries. Techniques for measurements of temperatures, gas pressure, released heat energy and composition of emitted gases were developed at Fraunhofer ICT.
- Influence of mechanical pressure on lithium-ion cell safety behavior, Fabian Ebert, Fraunhofer ISC, To identify the safety behavior of cells in a real world scenario, single and stacks of pouch-type cells were braced with different mechanical force and overcharged according to the UN38.3 standard. In comparison with the unbraced cells, the cells in the simulated module showed a significantly divergent safety behavior.

➢ Battery Production.

- Solutions for an electrified world, Markus Theine, KREISEL Electric GmbH & Co. KG, Kreisel has gained a lot of experience in the application of batteries in numerous projects for various applications of automobiles, trains, boats, energy storages, sports cars, construction vehicles, buses, trucks, and many others. In particular, the unique thermal management in conjunction with the cylindrical cell opens up numerous possibilities for tailor-made applications, preferably in the high-performance area. In addition to the comparison of battery-systems, the presentation will focus on the scope of technologies and the benefits of the cylindric cell, especially for the automotive sector, and how it can be deduced that even previously unidentified application areas can participate in the technology. Various business models and a cost analysis, as well as the chances of an easily industrializable and scalable product architecture complete the presentation.
- Relationship between Cost, Chemistry and Process, Dr. Stefan Permien, Custom cells Itzehoe GmbH, Main criteria for success of hybrid and full electric vehicles is the cost parity in comparison to combustion engines. The main cost-driver of an electric vehicle are the lithium-ion-cells. Reducing the amount of cobalt reduces the costs in the field of chemistry. Additionally, cell design, size and capacity have to be matched to the process and machinery in the production.
- From Single Cell to High Performance Battery Pack, Dr. Marcel Wilka, ANDREAS STIHL AG & Co. KG. Outdoor Power Equipment typically have smart Li Batteries with BMS and plastic housings and passive thermal management. Therefore, not only the cell characteristics are of particular importance for reliable battery packs but also the battery pack design and the coordination across the whole system. The presentation outlines the main characteristics and the methods and technologies required for developing high performance battery packs with high power and high energy density.

- From cradle to cradle - Efficient automation planning for the battery production, Stefan Bez, Manz AG. The enormous growing speed of the battery market is a pretty challenge for innovative machine manufacturers. Due to missing standards and high innovation grade it's necessary to meet the challenge to find an efficient way to develop machine and production concepts for individual customer solutions. Flexibility of processes for the next generations is a new dimension of an economic approach.

- Next Gen Materials,
  - Advanced Cell Materials, Dr. Kai-Christian Möller, Fraunhofer Battery Alliance, Contents: — Cell performance - Key parameters — Cell materials: State of the art and new developments — Cathode & anode materials, electrolytes & additives, separators — Performance, safety, cost aspects, market data — Raw materials, availability, recycling — New cell chemistries - risks and challenges: Lithium-sulfur, solid-state batteries
  - All-Solid-State Technology, Dr. Martin Finsterbusch, Forschungszentrum Jülich, Contents: —Ion conduction in solids —Solid-electrolytes - classses and properties —Ceramic cell fabrication —Performance and challenges —Applications and outlook. Li-ASBs have the potential to simultaneously increase the energy and power density while offering intrinsic safety. However, several challenges are faced during scale up and reliable determination of the optimization potential and development of design guidelines are thus important for a directed research and development.
  - Lithium Sulfur Technology, Dr. Holger Althues, Fraunhofer-Institut für Werkstoff- und Strahltechnik IWS, Contents: —Cell chemistry: Main components and conversion mechanisms —Cell performance: status and major challenges —Trends in scientific literature: new materials and cell concepts —Key factors for future cell development —Route towards commercialization: cell manufacturing and applications.

- Cell Production,
  - Cell Design und Manufacturing, Dr. Daniela Werlich, Custom cells Itzehoe GmbH Contents: — Cell chemistry — Cell design — New cathode materials — New anode materials — Silicon oxide — Cell manufacturing — Laminated separator
  - Global Cell Production Overview, Mike Sheppard, Power Technology Research LLC . With the increasing number of Electric Vehicles (EV) on a global scale, EV charging has become an essential aspect of car ownership. Joint ventures between automotive OEMs and charging solution providers are pushing for a pan-European ultra-fast charging network. First half of this session includes the market assessment around penetration of DC fast charging in the European region and its impact on power semiconductors market. Additionally, non-conventional charging technologies such as dynamic wireless charging also have a significant potential to reduce the range-anxiety and facilitate a widespread adoption of E-buses. The second half of this session includes current and future market potential for wireless charging along with detailed evaluation of a dynamic wireless charging case study.
  - Murata´s Portfolio of Power and Garden Tool Cells, Sato Yoichi, Murata Elektronik GmbH.
  - Next Generation Cell and Battery Sytems for 2025 - Potentials of a Raw Material and Cost Perspective, Robert Stanek, P3 group. Based on the P3 market forecast for eMobility, this presentation will cover the demand for battery production capacities worldwide. With

insights of Lithium-ion battery cell costs and supplier landscapes, P3 will introduce you to the potential and motivation of future technologies such as solid state electrolyte battery cells.

- Battery Management and Components
  - Integrated solutions to manage, monitor, gauge and protect battery packs, Kevin den Toom, Texas Instruments, Inc., Texas Instruments is proud to present decades of experience, developing integrated circuits to enhance your single and multi-cell battery application. Highlights include impedance track™ based battery fuel gauging, protection and authentication. We show methods to maximize power over lifetime and minimize system costs.
  - Battery protection in Power systems and high power equipment, Tom Thomson, Dexerials Corporation, The Self Control Protector is a fuse which protects the Li-ion battery in the secondary protection against overcurrent and overvoltage. This SCP will be used in several applications from lower current application as mobile phones to higher current application like e-scooters.
  - How to design safe battery systems with D6 SMD fuses, Christoph Stangl, Schott AG, SCHOTT SEFUSE® D6 battery fuses offer comprehensive protection in an extremely small surface mount design. The fuse protects li-ion batteries by cutting off the electric circuit in case of overcharging or overcurrent. For decades, SEFUSE® has been one of the most renowned and trusted brands of thermal fuses worldwide.
  - Effects of Battery developments in EV on Contactors and Protection circuits, Carol de Vries, Sensata Technologies, The effects of the latest developments in batteries for Electric Vehicles on Contactor performance requirements and protection circuits will be reviewed and the challenges highlighted, as well as key developments in this field.
  - Further development of over-current protection in HVDC battery circuits, Mitja Koprivšek, ETI Elektroelement d.d. Presented paper will show and explain further development of over-current electrical protection n HVDC battery circuits up to 1000Vdc. This protection is based on combination of Fuse and so called Pyro-switch technologies in order to provide the best and the fastest breaking of electric current and best electric arc mitigation.
  - Multifunctional Battery Housing in GVI Technology, Dr. Jobst Kerspe, KÖNIG METALL GmbH & Co. KG. Designing of battery housings means considering guidelines: thermal management - and the housing itself provides good thermal conditions independent from outside temperatures. Moreover, the housing keeps the battery safe under operating conditions as vibration and crash. Multifunctional battery housings integrate these functions in 1 device which is an important step to lightweight construction.
  - How Sealing Components can Improve Battery Safety and Reliability, Dr. Peter Kritzer, Freudenberg Sealing Technologies GmbH & Co. KG. An overview of Freudenberg´s battery components, which include separators & seals for Lithium cells as well as large format housing gaskets and sealing components for thermal management systems. A strong focus of the presentation is put on components and approaches which contribute to safety requirements of future battery systems. Here, heat shields, overpressure valves and pressure compensation concepts are presented. The speech shows both large-serial products, but shall also encourage the audience for common developments.

- Testing and Certification

- Effective data management in the battery test field, Thomas Wambera, AVL Deutschland GmbH, AVL is operating battery labs and supports many customers to operate efficient processes by providing lab management solutions for small labs up to factory sized assemblies. In this speech supporting IT solutions addressing the test lab and granting access to test parameters, data, scheduling options, test equipment, logistics and KPI of the entire development and testing process are showcased.

- Functional Safety and Battery Management
  - How Sealing Components can Improve Battery Safety and Reliability, Dr. Peter Kritzer, Freudenberg Sealing Technologies GmbH & Co. KG. An overview of Freudenberg´s battery components, which include separators & seals for Lithium cells as well as large format housing gaskets and sealing components for thermal management systems. A strong focus of the presentation is put on components and approaches which contribute to safety requirements of future battery systems. Here, heat shields, overpressure valves and pressure compensation

- Standards and Regulations & Fire Protection and Safety
  - Amendments 2019/2020/2021 focus lithium batteries: learning from burning, Prof. Dr. Norbert Müller, Schenker AG. The regulations for the transport of lithium batteries by all modes of transport have been modified routinely. The amendments for year 2019 and the consequences for the practical handling are presented. For companies which are involved in the transport of lithium batteries it is nearly a mission impossible to respect the provisions for 100 %. The presentation closes with an outlook on what was just decided for year 2021.
  - Worldwide Market Access for Lithium Batteries, Beat Kreuter, DEKRA Certification B.V. Contents: —Testing and certification —IEC and other standards —IECEE Global Certification —National Deviations and national certification
  - Lithium Battery Transport by Air, Eva Glimsche, Lithium-Batterie-Service GbR Contents: —Overview on the regulations (ICAO TI / IATA DGR) —Special Provisions —Packing Instructions —State of Charge —Marking/Labelling —Carriage in Passenger Baggage. UN Definition of damaged/defective or safety critically defective lithium cells and batteries. Risk assessment in your company. Checklist for returns. Special Provision 376, Packing Instruction P911 and LP906. Packing, Packaging, Marking/Labelling and Documentation in road and sea transport.
  - Reducing Risks for Lithium-Ion Battery Safety and Quality, Eda Coskun, REDUX Recycling GmbH. Lithium-ion batteries are dangerous goods and require professional safety standards. Careless handling can cause high damage. Considering the various standards and certifications is an important step in lithium-ion battery safety and quality, but it should not be the only one recyclers take. Redux Re-cycling GmbH has established various quality and safety factors.
  - Transport packaging for damaged and defective lithium batteries, Christian Breuer, Alex Breuer GmbH Industrieverpackungen. The transport of lithium batteries in the global intermodal supplychain is subject to regulations for the transport of dangerous goods. This presentation explains how to fully compliant use UN approved dangerous goods packaging for lithium batteries as well as for battery prototypes and damaged or defective batteries.

- Home Storage

- Charging,
  - Lucas Sturnfield, BMZ USA Inc. Contents: — Charging Profiles for common battery chemistries — Electro-chemistry and the energy storage mechanism — Concerns and failure modes in charging — Charging architecture, topologies, and infrastructure — Industry and Consumer trends that are impacting charging — System and Battery enhancements to optimize and improve charging
  - Fast Charging Li-Ion Battery Market 2018, Shmuel De-Leon, Shmuel De-Leon Energy, Ltd. Fast charging li-ion batteries for Automotive applications are mandatory for having EV for all. Owners of EV`s who have no charging spot at home can do a fast charging opportunity and still use the EV`s. Main problem for having fast charging EV batteries is the batteries themselves who can‘t be charge fast. Several companies are developing LI-Ion NMC cells that can be charge fast and can provide an energy density of `180 Wh/kg. The presentation review the needs and the main developers and progress achieved on that area
  - Inductive Charging for Electric Vehicles, Peter Wambsganß, WiTricity Corporation, Wireless charging of electric vehicles hit the market in July 2018 when BMW launched a factory-fitted, fully integrated inductive charging system for the BMW 530e iPerformance PHEV. The presentation reviews the fundamental technology and how magnetic resonance is used to design and commercialize efficient and cost effective wireless charging systems. An overview of the DRIVE 11 evaluation system which is WiTricity’s end to end reference design for wireless charging of electric and hybrid vehicles will be given. DRIVE 11 is capable of delivering up to 11kW of power at efficiencies up to 94% and compliant to SAE TIR J2954™ and IEC/ ISO standards.
  - Ultra-fast charging thanks to immersive cooling, Cédric Loubiat, Rémi Daccord, NEOGY, Lithium-ion batteries are powering a revolution in transport. Fast charging is viewed as an enabler for EVs mainstream adoption and will lead to a stronger heating of the cells. The recent addition of immersion to battery cooling strategies seems to be the latest improvement approach.

- Recycling,
  - Jonas Jeschke, REDUX Recycling GmbH Contents: —Lithium Ion battery markets & expected volumes —Recycling methods —Redux Recycling process —Recycling efficiency —Design for recycling.
  - The importance of Recycling for the electrification of verhicles, Charles Stuyck, Umicore AG & Co. KG. The LIB industry is facing a turning point in terms of market growth mainly due to the adoption of electrified cars (EV‘s). Tue need for a reliable and sustainable supply chain is hereby one of the most discussed topics in the industry. The purpose of this presentation is to weigh the role of the recycling industry in such a supply chain. To conclude, the presentation will attempt to summarize the current and future incentives for collectors and recyclers ofLi-ion batteries, starting from the rapidly changing needs of EV OEM‘s.
  - Recycling of secondary batteries - Challenges and potentials for a circular economy, Dr. Jens Peters, Helmholtz Institut HIU. Outline of potential resource constraints for secondary batteries, their environmental impacts and the potential of recycling processes for reducing these. Battery-specific challenges for closing material cycles and reducing impacts are pointed out, considering current and future cell chemistries.

KEY CONCULSIONS from the CONFERENCE

1. For coming next ~10 years dominating technology definitely is Lithium-Ion in NMC (or NCA) sub-chemistries. New developments are ongoing and are promising, however the time from R&D to industrial market must be maintained to assure overall safety of new energy solutions.
2. Dominating industrial cell sizes are 18650 and 21700. The latter can shortly prevail in most small/powerful (i.e. cordless tools) and medium size battery applications and for selected EV's (i.e. Tesla). Small pouch/prismatic cell models will stay main power source for portable electronics. Big pouch/prismatic cells are also still under consideration for EV's and big industrial systems.
3. The world is fully dominated by Asian manufacturers. If any factory in Europe is to start production, it is an Asian one. Today Swedish Nothvolt is the only one under construction, but details still not known. Tesla Europe still under consideration. TerraE or other purely German factory seems to be abandoned. But Volkswagen plans to start a factory in Germany with Northvolt as a partner, PSA (Peugeot/Opel/Citroen) and SAFT Batteries, plus French&German Governments and finally the EU Commission just decided to subsidy this initiative and start cell manufacturing factory. Situation is very dynamic.
4. This year (2019) situation on cells' market is much better than in 2018, there is enough manufacturing capabilities and still not so huge market demand (especially EV).
5. Situation for 2020 and beyond is extremely hard to predict. If EV industry starts as assumed, and especially at Chinese market (today ~60% of EV) and soon perhaps Indian markets, and the Energy Storage Systems follow, we may have deep shortages in cells' manufacturing. This may have huge impact on supplies of cells, because it is not possible to start new cell factories within short time. It is estimated that it would be necessary to start up to 10-15 Gigafactories worldwide to cover the demand.
6. Crucial issue for next years is ensuring the availability of cells. Long-term contracts with manufacturers and cell demand forecasting is the key to business growth.
7. Recycling is "a must" for worldwide battery industry, otherwise raw materials shortages can be serious "show-stopper" for the industry.